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ABSTRACT

Since the major causes of accidents are carelessness and a negative or apathetic attitude towards safety, this guide was developed to facilitate safe, stimulating science laboratory activities by providing both general and specific safety information presented in 12 sections. Subject areas considered in these sections include: 1) administrator/teacher/student responsibilities for laboratory safety and legal liability for laboratory accidents (includes extensive guidelines and safety audit checklists); 2) fire; 3) safety equipment and systems; 4) precautions for handling glassware; 5) compressed air, gases, and aerosols; 6) cryogenics (extreme cold); 7) model rocketry and balloons; 8) home chemistry sets; 9) science fairs; 10) chemistry, focusing on handling and storage of chemicals; 11) physics, focusing on the safe use of electrical equipment, radioactive materials, non-ionizing radiation, and lasers; and 12) biology, focusing on microbiological techniques, use of animals, experiments, and poisonous plants, including a list of plants, toxic part(s), and symptoms. A bibliography, list of supplementary resources (films and charts), and three appendices (first aid, wind chill factor, and thunderstorm hazards) are also provided. (JN)

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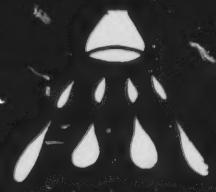

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PREFACE

In the last several years, there has been renewed interest shown about the issue of safety in school laboratories. The Manitoba Department of Education and the Manitoba Association of School Trustees sponsored science in-services dealing directly with the topic of laboratory safety. At the same time, a committee was established to revise the Safety in Science for Manitoba Science Teachers document published by the Department in 1973.

While no safety guide of reasonable size can contain all possible precautionary measures and warnings, the revised Laboratory Safety Guide has been compiled from sources believed to represent the best opinion on science safety as of December, 1980 and is intended to act as a starting point in the development and implementation of a school science laboratory safety program.

It is hoped that this guide will be of a significant help to science teachers in planning their lessons and in outlining correct safety precautions to their students. By following the recommendations in this guide, the students should develop proper science safety skills and attitudes towards scientific experimentation. Comments and suggestions for improvement of this guide are invited. Please address them to:

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INTRODUCTION

The purpose of this guide is to facilitate safe, stimulating science laboratory activities. The material focuses on the development of positive attitudes to safety and the proper use of laboratory equipment. The major causes of accidents are carelessness and a negative or apathetic attitude towards safety. On the other hand, positive attitudes to safety, accompanied by relevant information, can result in exciting and stimulating experimentation in a safe environment.

This document is a comprehensive science safety guide containing material from the best available sources. All specific curriculum needs could not be anticipated because interim science curriculum guides were under revision at the time of the writing of this guide. However, it is anticipated that updating information will be distributed as new needs become identified. There is some intentional repetition of information in each section because of the overlap in the various disciplines. However, individual chapters are devoted to Chemistry, Physics, and Biology.

A school environment in which safety awareness and practices grow and become an integral part of the lives of our students will provide a safe and rewarding educational experience. Safety habits have far-reaching implications - a safety conscious student today is the safety conscious adult of tomorrow.

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I. RESPONSIBILITIES FOR LABORATORY SAFETY

A. Administrative Responsibility

The overall impetus for laboratory safety throughout the school system should come from the administration. This can be accomplished by:

- providing the proper science facilities throughout the school system;
- providing safety equipment wherever needed; and
- providing safety instruction by way of manuals, films, in-services, and resource information.

The following is a possible set of guidelines for principals and science supervisors:

1. Establish a safety committee within each school with a mandate to develop the basic safety program for the laboratories and other areas of the school and ensure that the program is maintained.
2. Ensure that a safety audit is performed at least once and preferably twice annually.
3. Give immediate attention to the Laboratory Safety Audit completed by science teachers and facilitate repairs and purchasing of all necessary safety equipment.
4. Emphasize laboratory safety at science department or staff meetings.
5. Make all science teachers and laboratory assistants aware of hazards and the seriousness of accidents periodically, through departmental conferences at the beginning of each year, or during in-service sessions.
6. Try to assign teachers with a science background to science courses.
7. Assign to a science class only the number of students that can be accommodated safely within the working space.
8. See that a properly stocked and labelled first aid kit is present in each science laboratory and preparation room or in an easily accessible place. At least one copy of a current booklet on first aid should be kept with each first aid kit.
9. Have first aid kits and fire extinguishers inspected at least once a year.
10. Make teachers aware of personnel in the school who have first aid training.
11. Establish procedures in the event of fire.
12. Provide opportunity for first aid and CPR certification training for all science staff.
13. Explain the safety program to the parents at Home and School Association meetings and request the cooperation of parents in stressing safety in the out-of-school activities of the students.

B. Teacher Responsibility

1. Basic Guidelines

It is obvious that the safety techniques, procedures, and attitudes of teachers have a major influence on students. Thus, the most effective ways of teaching safe procedures are by providing a special unit on safety, developing and maintaining laboratory regulations, and setting a good personal example involving the following traits or attitudes:

- Careful observation
- Constant alertness
- Concern for accuracy and precision
- Criticism of experimental procedures
- Recognition of safety considerations in experimental design
- Conscientiousness toward the laboratory exercises

Probably the most important function of the teacher in accident prevention is the effective surveillance of all student activities. Even students who are well acquainted with appropriate practices are often prone to attempt short cuts or to neglect certain portions of the normal routine. A watchful teacher will take immediate action and remind such students of the need for attention to details. The teacher should also require a routine in which all students would conduct a mental safety check of any apparatus prior to beginning its operation.

Most teachers are careful in avoiding accidents and in the manipulation of apparatus. However, in the interest of safety, each teacher should observe the following guidelines:

1. Complete the safety audit checklist and submit the checklist to the administration.
2. Complete a teaching unit on laboratory safety.
3. Prepare a set of student regulations for the laboratory. Make sure the students are aware of these regulations.
4. Perform classroom experiments only if you have previously tried them out or have been properly instructed by one who is familiar with the necessary procedures. Do not work alone - have another teacher present.
5. Brief students thoroughly on the danger areas for each experiment before starting the experiment. Provide written laboratory procedures which include the details regarding safety considerations for the specific experiment.
6. Circulate among students during lab periods.
7. Stay in the laboratory or ensure adequate supervision.
8. Discourage any form of "horseplay" in the laboratory.
9. See that pupils do not handle hazardous substances in an unsupervised situation.
10. Make certain that protective eye wear is available in all necessary locations and that its wear is mandatory for all teachers, visitors, and students wherever and whenever eye damage can occur.
11. Make fume hoods available for any activity involving flammable or toxic substances. Chemistry laboratories should be equipped with functional fume hoods.
12. Use safety shields or screens whenever there is potential danger that an explosion or implosion of apparatus might occur.
13. Be familiar with the potential hazards of all materials and equipment in the laboratory.
14. Observe the following guidelines when using alcohol burners:
    a) Recognize the explosive potential of a can of denatured alcohol. The portion above the liquid consists of alcohol vapors which are highly flammable and potentially a powerful explosive hazard.
    b) Use ethyl alcohol (denatured 95%) rather than methyl alcohol which has a lower flashpoint.
    c) Use metal alcohol burners if possible. Discard and replace them when corrosion is evident.
    d) Adjust wick so that the exposed part is short and trim.
    e) Extinguish all flames in the laboratory before filling alcohol lamps.
    f) Always tighten the top of the lamp before igniting and replace the metal cap top when lamp is not in use.
    g) Place on a heat resistant pad.
    h) Do not permit students to carry lit burners from the working area.
    i) Never allow lit burners to be unattended.
    j) Remember, an alcohol flame is hard to see. If a lit glass alcohol lamp is dropped and breaks, the flame can cover a large area instantaneously.
15. Store alcohol or other flammable liquids such as ether, gasoline, carbon disulfide, hexane in a specially designed room away from the

laboratory itself or in a ventilated metal cabinet equipped with a workable locking mechanism.

16. Ensure that all storage bottles are appropriately labelled. (See the section on labelling.)
17. Dispose of chemicals found in unlabelled bottles according to proper procedures as prescribed by the Department of Environmental Management. Any unused chemical should not be returned to its container.
18. Do not place bottles containing organic volatile liquids or concentrated acids near heated pipes, in direct sunlight, or above the bottom shelf in the storage room.
19. Take precautions whenever pressure buildup within a container presents a potential for explosion; e.g., concentrated hydrogen peroxide, nitric acid, and chromic acid cleaning solution.
20. Do not seal containers of dry ice.
21. Flush deluge showers and eye wash stations on a regular basis.
22. Request that each science laboratory be equipped with a first aid kit.
23. Know the location of the master shut-offs and how to turn off the gas and electricity.
24. Be sure all gas lines are shut off at the end of each class session.
25. Be sure all gas jets have been turned off prior to opening the gas line.
26. Inspect all electrical equipment, especially their cords and plugs, for dangerous signs of wear or faulty connections.
27. Arrange for any demonstrations, experiments, or projects dealing with atomic energy or radioactivity to be performed in accordance with safety practices in that field.
28. Consider that new products may contain new properties and thus present the possibility of a new hazard.
29. Display original or commercially available posters dealing with safety procedures in the laboratory when appropriate.
30. Use original or commercially available labels dealing with safety hazards of chemicals and/or equipment.
31. Use wax or some other means to protect labels on containers.
32. Make certain that poisonous and otherwise dangerous materials are maintained in a safe, controlled, storage area.
33. Keep laboratories and storage areas locked when they are not supervised by a responsible person.
34. Inspect chemicals in the storage area at least once a year. Keep records of these inspections. All chemicals should be dated upon receipt and labelled according to the 704M System.
35. Be knowledgeable in the use and selection of the appropriate fire extinguisher and safety procedures in the event of fire. See that fire extinguishers are recharged immediately after use.
36. Immediately report to the appropriate authorities any serious injury or accident and initiate a full investigation.
37. Become familiar with bulletins regarding dangerous chemicals and take the necessary precautions.
38. Be aware of potential danger when opening packages from supply houses. For example, previously broken glassware may have been removed from the packing or the styrofoam forms, but pieces of sharp glass may still be left to cut the hands of unwary teachers when in the process of unpacking.
39. Check for cracks and leakage from broken containers of reagents from supply houses, and transfer contents to proper containers.
40. Be familiar with current first aid treatment and receive certification in a recognized first aid course. Training and certification in CPR is also desirable.
41. Never assume that experiments are free of safety hazards just because they are printed.
42. Encourage students to carry out safety procedures in their out-of-school activities.

2. Safety Audit

The prevention of accidents and resulting injuries is accomplished by providing safe surroundings and safe work methods. Remember, the majority of accidents can be prevented.

The safety audit is a full job-hazard analysis, conducted on a semi-annual or annual basis.

The purpose of the safety audit is to:

a) assist in locating possible areas of concern and danger;
b) recommend corrective action for deficiencies;
c) provide for an effective follow-up;
d) act as a permanent record of an ongoing safety program; and
e) act as a record in the event of court action.

The following safety audit is intended to serve as a guide. The teacher should modify it through additions and deletions to suit a particular situation.

3. Safety Audit Checklist

Complete the following pages for your laboratory. Send one copy to your principal, and keep one copy on file for yourself. Repeat at least annually.

NAME _____ DATE _____

TITLE _____

SCHOOL _____

DEPARTMENT _____

LOCATION: CITY _____ PROVINCE _____

1. a) Number of exits per laboratory _____

   b) Are exits kept clear? Yes _____ No _____

   c) Are exits properly marked? Yes _____ No _____

2. a) Do storage rooms have locks? Yes _____ No _____

   b) Are storage rooms properly marked? Yes _____ No _____

   c) Are storage shelves permanently fixed to the wall? Yes _____ No _____

3. Number of fire extinguishers

	Type		Location
a)	A (Water Type)	_____	_____
b)	B (Dry Chemical Type)	_____	_____
c)	C (CO_2 Type)	_____	_____
d)	ABC (Multipurpose Dry Chemical Type)	_____	_____
e)	D (Dry Powder Type)	_____	_____

4. Last inspection date for fire extinguishers _____

5. Are fire extinguishers fully charged? _____

6. Number of sand buckets w/sand _____

7. Number of approved fire blankets _____

8. Number of first aid or emergency charts _____

9. Number of first aid kits w/supplies _____

10. Number of safety showers _____
Are they operable? _____

a) Industrial type _____

b) Hand or portable type _____

11. Number of eyewash stations _____

a) Installed w/plumbing and aerifier _____

b) Other _____

c) Are they checked regularly to determine operability? _____

12. Eye, face, and body protection

a) Number of approved safety glasses w/full side shields _____

b) Number of approved safety chemical goggles _____

c) Number of approved plastic face shields _____

d) Number of demonstration safety shields _____

13. a) Does each student have his/her own personal eye protection device? Yes _____ No _____

b) If answer is no, is there a maintenance and cleaning program? Yes _____ No _____

14. Number of rubber gloves _____

15. Number of rubber/plastic/cloth aprons _____

16. Number of heat resistant gloves (pairs) _____

17. Number of lab coats _____

18. a) Number of electric outlets (110-120 volt with ground) _____

b) Are ground fault interrupters installed? Yes _____ No _____

c) Are transformer isolation systems installed? Yes _____ No _____

d) Number of electric outlets (110-120 volt without ground) _____

19. Is provision made for proper grounding of all electrical devices? _____

If no, please describe _____

_____

_____

20. a) Number of compressed gas cylinders _____

b) Are they properly secured to prevent tipping? Yes _____ No _____

21. Number of sinks _____

22. a) Number of waste receptacles for glass _____

b) Number of waste receptacles for dry chemicals/reagents _____

c) Number of waste receptacles for liquid chemicals/reagents _____

d) Are all waste receptacles properly marked? Yes _____ No _____

e) Are all waste receptacles easily located? Yes _____ No _____

23. Number of containers designed to transport dangerous reagents or chemicals _____

24. a) Number of securable storage spaces for chemicals w/forced ventilation _____

b) Number of securable storage spaces for chemicals without forced ventilation _____

25. a) Number of electric refrigerators _____

b) Number of explosion-safe refrigerators _____

26. Briefly describe what type of materials are stored in these units, such as reagents, food, etc.

a) Electric refrigerators _____

_____

b) Explosion-safe refrigerators _____

_____

27. a) Number of fume hoods _____

b) Is the exhaust velocity adequate? (30 m/sec. minimum) _____

c) Is the fume hood rated explosion proof? _____

28. a) Number of room exhaust fans _____

b) Rated exhaust velocity _____

29. a) Number of vented cabinets to store hazardous or flammable chemicals _____

b) Number of non-vented cabinets to store hazardous or flammable chemicals _____

30. Number of safety cans to store hazardous or flammable chemicals _____

31. Is there a master cutoff for gas in the laboratory? Yes _____ No _____

32. Is there a master cutoff for electricity in the laboratory? Yes _____ No _____

33. Are the utility cutoffs accessible? ____ Do you know where they are? Yes _____ No _____

34. Are the floors non-skid? Yes _____ No _____

35. Is there sharp-edged furniture in the laboratory? Yes _____ No _____

36. Number of smoke detectors in the science labs and storage areas _____

37. Number of heat detectors in the science labs and storage areas _____

38. Is there a sprinkler system in the science labs and storage areas? Yes _____ No _____

39. Is there an emergency light system in the science labs and storage areas? Yes _____ No _____

40. Do the doors of the storage rooms and preparation areas

a) Have interior crash bars? Yes _____ No _____

b) Open outward? Yes _____ No _____

41. a) Number of gas burners _____

b) Number of alcohol burners _____

42. Do you use live animals in the lab? ____ If so, are there proper facilities to handle and care for them? Yes _____ No _____

43. Are you aware of the biohazards involved in animal handling? Yes _____ No _____

44. a) Are experiments conducted using biologic fluids? Yes _____ No _____

b) What is the source? _____

45. a) Does blood-letting experimentation take place? Yes _____ No _____

b) If so, are disposable lancets and alcohol swabs used? Yes _____ No _____

c) Are they discarded after one use? Yes _____ No _____

46. Do you permit handling of pathogens by students? Yes _____ No _____

If yes, explain _____

_____

47. Do you autoclave all microbiological specimens before disposal? Yes _____ No _____

48. Do you have pipette bulbs for proper pipetting procedures? Yes _____ No _____

49. Is food preparation/consumption/storage permitted in laboratory? Yes _____ No _____

50. Do you have proper facilities to accommodate the handicapped student? Explain below. Yes _____ No _____

_____

_____

_____

51. Do you store your chemicals as per recommended systems? Yes _____ No _____

52. Do you have adequate spill control equipment? Yes _____ No _____

53. Do you perform your chemical audit at least annually? Yes _____ No _____

54. a) Do you dispose of your unwanted chemicals as per recommended methods? Yes _____ No _____

b) Have you disposed of <u>all</u> unlabelled chemicals? Yes _____ No _____

55. Is there a standard accident investigation procedure? Yes _____ No _____

56. Teacher Recommendations (Summary of Findings)

a) Adequate _____

_____

_____

_____

_____

b) Inadequate _____

_____

_____

_____

_____

C. Student Responsibility

Schools should follow the very best of safety practices. Students in science laboratories should become so familiar with good safety procedures that they follow them automatically. Positive student attitudes toward safety are imperative. Students should not fear doing experiments, using reagents, or equipment, but they must recognize the potential hazards and act accordingly. To guarantee continuing safety, students should become familiar with the health and safety hazards of all equipment and chemicals used.

Common accidents in the classroom or laboratory fall into three categories: cuts from broken glassware, burns from hot apparatus, and chemical burns. The number of each of these classes of accidents can be reduced by increased caution on the part of students.

The following rules are suggested; teachers are encouraged to modify this list according to their particular classroom and laboratory situations. It is strongly recommended that each teacher establish, post, and frequently review rules and procedures with the students.

1. Keep a copy of your safety instructions in your laboratory workbook at all times.
2. Be alert and proceed with caution at all times in the science laboratory. Remain in your lab station while performing an experiment, taking care not to bump another student. Never rush, but always be prepared to stop quickly. Horseplay or practical jokes of any kind cannot be tolerated.
3. Know the location of the emergency shower, eye and face wash fountains, first aid supplies, fire blanket, and fire extinguishers and know how to use them.
4. Know the proper fire drill procedure. When the fire alarm rings, shut off all burners. If time permits, stabilize the equipment.
5. Know the location of the fire blanket. If clothing should catch fire, smother the fire with the blanket.
6. Prepare for each laboratory activity by reading all instructions before coming to class. Follow all directions implicitly and intelligently. Make note of any deviations announced by your instructor.
7. Study the purpose of an experiment before performing the experiment.
8. Do not assume that experiments are free of safety hazards just because they are printed.

9. Be under the direct supervision of a teacher at all times in the laboratory or wherever experiments are performed.
10. Do not leave experiments unattended. An unattended experiment can result in an accident.
11. Never attempt unauthorized experiments. No laboratory work may be carried on without the teacher's permission.
12. Bring only lab manuals and lab notebooks in the working area. All other books, as well as personal possessions, should be placed in your desk or storage area.
13. Keep work areas clean and tidy. Good housekeeping is essential in maintaining safe laboratory conditions.
14. Do not touch laboratory equipment, chemicals, live animal specimens, or poisonous plants until directed to do so.
15. Use only materials and equipment authorized by your instructor. Be sure that you are using the correct items and that you know how to use them.
16. Do not carry laboratory apparatus through hallways while students are in transit.
17. Never carry hot equipment through a congestion of students.
18. Do not bring food or beverages into any science laboratory or use laboratory equipment for food preparation. Do not smoke in the lab.
19. Do not go into laboratory storage rooms or teacher work rooms unless directly instructed to do so.
20. Wear appropriate apparel for laboratory work:
    a) Never wear expensive clothing if laboratory work is to be done. An old shirt will give your clothes some protection if a lab coat is not available. Long sleeves should be rolled up above the wrist.
    b) Do not wear dangling necklaces, ties, bulky jewelry, or excessive and bulky clothing in the laboratory.
    c) Wear proper footwear at all times. Open-toed sandals should not be worn in the laboratory.
21. Wear nets or tie-back long hair near open flames or in other hazardous situations. Precautions should be taken when wearing loose clothing near a flame.
22. Use extreme caution with alcohol lamps, especially if they are the glass-type.
23. Never transport a burning alcohol lamp. If a hot glass alcohol lamp is dropped and breaks, the flame can cover a large area instantaneously.
24. Exercise extreme caution when using a burner. Keep your head and clothing away from the flame and turn it off when not in use.
25. Light gas burners with a sparker in accordance with instructions.
26. Never leave an almost colorless Bunsen flame unattended. If the burner is to be kept lit, shut off the air vent and decrease the gas supply to produce a flame resembling that of a candle.
27. Do not bring any substance into contact with a flame, unless specifically instructed to do so.
28. When heating contents in a test tube, treat it like a loaded gun: never point it in anyone's direction. Hold the tube at an angle and heat it from the top down, keeping the tube moving in the flame. While being heated, a test tube should never be more than half full. Generally, a water bath is more suitable for heating liquids in test tubes.
29. Do not throw matches, litmus paper, wooden splints, or toothpicks into wastepaper baskets.
30. Use an enclosed electrical heat source when alcohol or other flammable liquids must be heated. Steam heat is even better, if available.
31. Be careful in heating flammable solvent that it is not allowed to come into contact with an ignition source.
32. Use heat-safety items such as safety tongs, heat resistant mittens, aprons, etc.
33. Use the proper type of tongs when handling hot crucibles or beakers. Crucibles must be held at the very end of crucible tongs. Place hot

crucibles on a heat resistant square or on the base of a ring stand. Do not allow hot objects to contact the counter table tops.

34. Place an inverted beaker above the evaporating dish when evaporating a solution to dryness. If available, use a hot plate with a temperature control, or heat lamps.
35. Wear proper eye protection devices when supervising or observing science activities involving potential hazards to the eye.
36. Do not wear contact lenses during laboratory experiments. They offer no protection in themselves and are unsafe even under safety goggles.
37. Use approved goggles when working with dangerous chemicals, hot liquids or solids, radioactive materials, and other potential sources of splashes, spills, or spattering.
38. Use a sharp file to cut small-diameter glass tubing. First, make a deep scratch, then wet the scratch and wrap the tubing in a paper towel before applying pressure on the glass and away from you with your thumbs. Fire polish all ends.
39. Report sharp edges on mirrors, prisms, glass plates, metal plates, etc., to the teacher so that they can be removed. Do not work with glass tubing that has jagged edges or edges which have not been fire polished.
40. Observe the following precautions when inserting glass tubing or rods into rubber stoppers:
    a) Fire-polish or bevel with a file, emery stone, or sandpaper the jagged edges of tubing.
    b) Use glycerin as a lubricant and insert the tube by using a twisting motion. Do not use glycerin if the assembly is to be exposed to nitric acid.
    c) Always hold the tubing as close to the stopper as possible.
    d) Use a "grip-save" or wrap a cloth around your hand or over the end of the tubing.
41. Check bent glass tubing to ensure that a flow of gas is not obstructed.
42. Remove glass thermometers or tubing as soon as possible after use to prevent the glass from 'freezing' to the stopper. If the glass has frozen, either split the stopper with a sharp knife or bore the tube out of the stopper with a cork borer.
43. Handle glass and steel wool carefully to avoid splinters and cuts.
44. Use ring stands as well as wire gauze and a ring clamp to secure erlenmeyer and florence flasks.
45. Remove broken glass from work area or floor as soon as possible. Never handle broken glass with your bare hands. Use a counter brush and dustpan and/or wet cotton wads held with forceps and dispose in proper containers.
46. Place broken glassware in special garbage containers. Be especially careful not to leave broken glass on benches or in sinks.
47. Report such things as broken equipment and "suspicious-looking" chemicals to the teacher.
48. Pull the plug and not the cord when removing an electric plug from its socket. Report frayed cords to the teacher. Bare electrical wires can be extremely dangerous.
49. Read the label on a chemical bottle at least twice before removing a sample. This is a standard procedure in industry and pharmacies.
50. Keep the caps or stoppers tightened on chemical containers at all times, except in cases where a volatile product may result.
51. Never return unused solutions to stock containers or reagent bottles.
52. Never drink from any laboratory glassware.
53. Never taste chemicals unless directed to do so by the instructor.
54. Keep hands away from the face, eyes, and body when using solutions, specimens, equipment, or materials in the laboratory.
55. Never handle mercury with your hands. It will ruin gold or silver jewelry on contact. Mercury vapors are highly toxic.
56. Waft odors toward your nose with your hand. Never breathe them directly.
57. Perform experiments under a fume hood when flammable, objectionable, or poisonous gases are to be produced.

58. Be especially careful with organic solvents; many of them are highly flammable and some are toxic. Use under a fume hood if possible.
59. Dispose of rags containing highly flammable organic solvents and any explosive waste chemicals in a fireproof receptacle.
60. Use a suction bulb in filling pipettes with chemical reagents. Never use mouth suction.
61. Learn and use the correct technique for pouring liquids from reagent bottles. Hold the glass stopper above the hand and between the index and middle finger so that the same hand can grasp the bottle. When pouring chemicals from beakers, use a stirring rod to direct the flow.
62. Wear gloves when handling corrosive reagents.
63. Add acid to water when diluting concentrated acid. Pour the acid slowly and carefully into the water. Stir gradually to spread heat.
64. Acids spilled on skin, clothing, or laboratory areas should be neutralized with copious amounts of water or sodium bicarbonate.
65. Bases spilled on skin, clothing, or laboratory areas should be neutralized with copious amounts of water, boric, or diluted acetic acid.
66. Irrigate the eye(s) without interruption for fifteen minutes, if an injury occurs.
67. Beware of what may appear to be drops of water on laboratory benches. They may be corrosive liquids.
68. Report to the teacher at once any personal injury, scratch, burn, cut, or corrosive liquid on skin or clothing.
69. Flush the sink with copious amounts of water after disposing of chemicals in the sink.
70. Place all solid waste in separate waste baskets, jars, or other designated receptacles. Do not discard any solids in the laboratory sinks, especially glass items such as tubing or cover glasses.
71. Clean and wipe dry all desks, tables, or laboratory work areas at the conclusion of each laboratory activity.
72. Wash hands thoroughly with soap at the conclusion of each laboratory period.
73. Make certain all hot plates, open burners, and gas outlets are turned off before leaving the laboratory.
74. Be aware of the possible hazards involved in activities outside the school, e.g., mixing chemicals to "see what happens," setting fire to gasoline cans, breaking open flourescent tubes, and incinerating, puncturing, or any other unnatural use of aerosol cans.
75. Report any blasting caps lying around to the police and do not touch them. The Explosives Act of Canada makes the manufacture of explosives unlawful except under proper licence.

D. Legal Liability for Laboratory Accidents

1. Introduction

The legal liability of teachers and schools for injuries resulting from laboratory accidents is generally the same as their liability for any type of accident which occurs to students or visitors on or about school property.

Teachers can be held liable for negligent acts resulting in personal injuries to students. A brief summary of legal principles and means of preventing laboratory accidents is presented in the following paragraphs.

Teachers have two basic duties: instruction and supervision. Activity-oriented teachers, including science teachers, have an additional basic duty which is the proper maintenance and upkeep of all equipment and supplies. The science teacher should inspect all equipment and chemicals at least once per school term or semester and notify the principal in writing of any deficiencies. The use of the Laboratory Safety Audit is recommended.

Students should not be permitted to take part in any activity without first being given complete instructions from the teacher. These instructions would include:

a) An explanation of the basic procedure involved - both written and verbal.
b) An explanation of what to expect while performing the activity.
c) The identification and clarification of any risks involved.
d) An explanation of the behaviour expected from students during the activity.

2. Tort

When students are injured during activities, the teacher's conduct may be investigated. The investigation may discover a tort which is defined as a wrongful act causing personal injury or property damage for which legal proceedings may be instituted.

Non-intentional interference with a person's interest is covered by the concept of negligence from which the basis of tort liability is derived.

3. Negligence

Negligence is defined as conduct falling below a standard of care established by law to protect others against an unreasonable risk of harm. The standard of care is either established by statute or by measuring the conduct of an individual against what a reasonably prudent individual would have done, given the same circumstances. The reasonably prudent individual is able to anticipate where difficulties may occur and would not direct a student to take part in an activity without giving sufficient instruction and supervision.

Coverage of legal liability is too extensive to cover in this publication, but the following summary of the elements necessary to prove negligence may be helpful:

a) Failure to perform legal duty - teachers and boards may be found liable if their conduct falls below a commonly accepted standard of care towards those to whom they owe a duty.
b) Failure to maintain standard of care - teachers stand in the position of a parent or unofficial guardian. Teachers and boards must see to it that no lack of reasonable care on their part leads to harm being done to others on their premises.
c) Close causal connection between conduct and injury - negligence was the direct cause of the injury.
d) Proven loss or damage - there must be proof that the plaintiff has suffered actual injury or loss.

4. Insurance

All school boards belonging to the Manitoba Schools Insurance Program have purchased liability insurance to protect themselves against negligence claims. Liability insurance protects the school board from financial loss when the board or its agents are found negligent and thereby legally liable for causing injury to others or damage to property. Teachers, other employees, and volunteer workers are protected while acting on behalf of the board. All school boards insured under the Manitoba Schools Insurance Program carry $10,000,000 liability.

It is believed that any school boards in Manitoba which are not members of the Manitoba Schools Insurance Program have purchased liability coverage from a private carrier. School divisions and districts are

insuring themselves against third party claims which may arise from accidents or injuries in one of their establishments whether the school division (district) or its employees, or both, were negligent in their duty. The law states that an employer is responsible for the action of his employees, and an employer would usually indemnify his employees against third party claims during the course of their employment. The Manitoba Teachers' Society also carries a liability insurance policy on behalf of its members, and information on the coverage may be obtained from the Society.

Generally, employees would be protected from third party claims if they were acting in the course of their employment when injury or damage occurred. School divisions or districts would ordinarily defend and indemnify their employees against third party claims arising during the course of their employment.

5. Transportation Insurance

School divisions and districts that are insured under the Manitoba Schools Insurance Program have the necessary coverage for school-sponsored activities on a worldwide basis. This would include science fairs and field trips.

The majority of school boards have also purchased the necessary insurance to cover transportation on school-sponsored field trips.

Teachers should, however, check with their school board office before undertaking any trips as some boards have different types of coverage, and only certain drivers may be covered. As a general rule, the board office must be informed prior to any field trips or special outings.

By anticipating dangers and accidents in school science projects, teachers and authorities can take the necessary steps to prevent them and to avoid the possibility of injury, property damage, and liability suits.

II. FIRE

A. In Case of Fire

	DO	DON'T
1.	Give the alarm.	
2.	Use the proper extinguisher to extinguish small fire.	Try to extinguish a fire if you do not have the proper equipment or if the fire is too large.
3.	Go to the nearest exit if evacuation should be necessary.	Remain in exit paths, or return to the fire location.
4.	Use the stairwells for evacuation where possible.	Use the elevators.
5.	Handle fire-fighting and evacuation procedures in an orderly and calm manner.	Panic!
6.	Turn off all utility services if time permits (electric, gas).	
7.	Stabilize laboratory equipment if time permits, e.g., disconnect delivery tubes from water.	
8.	Congregate in an emergency evacuation area.	Remain at entrances and/or re-enter the building.
9.	Drop immediately to the ground and roll in a fire blanket if clothing catches on fire. Use a safety shower if immediately available.	Run so that the fire is fanned.
10.	Crawl close to the floor and breathe through a wet handkerchief if caught in smoke or fire.	
11.	Complete a fire investigation form after a fire in the laboratory to discover causes and future preventive measures.	

B. Fire Extinguishers

Having the appropriate fire extinguisher on hand is an important factor in control of fire. Although fire regulations often require the extinguisher only to be located near the door, it is often desirable to have a second or even third extinguisher available in strategic locations in the laboratory, where they are liable to be needed.

1. Types of Fires and Fire Extinguishers

	Appropriate Extinguisher						
	A Water Extinguisher	B Dry Chemical	C CO_2 Type	D Dry Powder	A BC Dry Chemical	Dry Sand	Fire Blanket
Active Metals (Mg,Na, K,or Li)				X		X	
Wood, Paper, Textiles	X				X		
Flammable Liquids		X	X		X		
Electrical			X		X		
Clothing							X

The teacher and students should learn to recognize the different types of fires and to select the appropriate extinguishers. In addition, each teacher should have experience using the extinguisher(s) in a practical demonstration, paying attention to such things as the distances to stand from the fire, the way to aim the spray at the base of the fire, and the effectiveness of the technique.

2. Care and Location of Fire Extinguishers: A Checklist

a) Are the extinguishers fully charged?
b) Are the pins in place?
c) Is there any visible sign of damage?
d) Are the extinguishers checked yearly?
e) Are they clearly marked as to class and use?
f) Were they recharged after they were used?
g) Are their locations clearly marked by signs?
h) Are they located conveniently to the areas of use?
i) Are they mounted on brackets?
j) Are they mounted at an accessible height?

III. SAFETY EQUIPMENT

A. Eye Safety Devices

1. Introduction

An eye safety program and the provision of relevant protective devices are important in all laboratories in which there is the heating, breaking, or cutting of glassware, the use of chemicals, and the use of apparatus or materials under stress or at above or below atmospheric pressure.

2. Selection of Appropriate Eye Protection

The particular job to be done determines the type of eye protection needed. Additional considerations when selecting devices include the comfort to the wearer, the durability, the expense, and any special recommendations by authorities.

The following chart (page 18) provides a comparative assessment of the most common eye protective devices.

3. Strict standards for the maintenance and cleanliness of eye protective devices should be maintained.

   a) Each type of device should be kept in a definite, readily accessible location, and their distribution and return to storage should be by established routine.
   b) If possible, students should purchase their own pair of goggles, especially if they have unhealthy, possibly contagious, skin or eye conditions.
   c) If goggles must be shared, they should be sterilized before each use by washing with a diluted disinfectant, followed by a thorough rinsing. Ultraviolet cabinets for sterilization are highly recommended.

B. Clothing and Skin Protection

1. Personal Wearing Apparel

   a) Dangling necklaces, ties, bulky jewelry, or excessive and bulky clothing should not be worn if laboratory work is to be done.
   b) Open-toed shoes or sandals should not be worn in the laboratory.
   c) Expensive clothing, jackets, coats, cardigan sweaters should not be worn if laboratory work is to be done.

2. Laboratory Coats

   a) A laboratory coat acts as an initial barrier to chemical spills, and can easily be removed if the spill is substantial.
   b) If possible, flame resistant laboratory coats should be used:
      - Wool is the least flammable of the common fabrics. It is a self-extinguishing natural fibre.
      - Nylon melts when heated and builds up static. Nylon sometimes "explodes."
      - Disposable plastic aprons are highly flammable. Do not use them for any experimentation requiring the use of flames.
      - Brushed cotton clothing may flash when ignited.
      - Denim is moderately safe in the laboratory.
   c) If coats are not available, an old shirt, with the sleeves rolled up to prevent flapping, may be used as a lab coat for most activities.

EYE PROTECTIVE DEVICES

COMPARISON CHART

Type	Front Splash Protection	Side Splash Protection	Front Impact Protection Flying Object	Side Impact Protection	Neck and Face Protection	Wearer Comfort	Student Accept-ability	Life Time Use	Expense
Glasses (without shields)	Good	Poor	Excellent	Poor	Poor	Good to Very Good	Very Good	Very Good	Moderate
Glasses (with shields)	Good	Good	Good	Fair	Poor	Good	Good	Very Good	Moderate
Goggles	Excellent	Excellent	Excellent	Excellent	Poor	Fair	Poor	Fair	Moderate to Expensive
Face Shield (various sizes)	Excellent	Good to Excellent	Excellent (if ade-quate)	Good to Excellent	Depends on type and length	Fair	Good for Short Periods	Fair	Moderate (depending on type)

Notes: Specific filter lenses must be employed when welding, glass-blowing, or using high intensity light sources or lasers. It is best to select goggles which have N.I.O.S.H. or O.S.H.A. approval. Alternately, one may submit a sample of the goggles to the Workplace Safety and Health Branch, Manitoba Department of Labour for examination and approval.

3. Gloves

Rubber, disposable, and heat resistant gloves should be available in the laboratory for use as appropriate to the activity being undertaken.

4. Hairnets and Ties

Students whose hair is long enough to become entangled in apparatus, or to obstruct vision, should wear adequate hairnets or tie their hair back.

C. Ventilation and Exhaust Systems

1. Laboratories, by the very nature of the activities carried on in them, require a higher rate of exhausted air than some other occupational environments. The type of exhaust system required depends upon the particular hazards of those activities. In cases where special fume hoods are required it is often impossible to use them for general ventilation without either posing a serious health hazard or damaging some components of the hood.

2. Laboratory ventilation should meet the following general requirements:

   a) General laboratory ventilation should be sufficient to ensure an adequate supply of clean wholesome air under peak load conditions.
   b) Contaminated air which is exhausted from a laboratory should not be recycled through the remainder of the building.
   c) Ventilation should be maintained at a rate to ensure that the air pressure in the laboratory is slightly negative with reference to adjacent halls and rooms not used as laboratories.
   d) In laboratories where the activity which is being conducted produces hazards of little or low toxicity, sufficient general ventilation may be adequate.
   e) Where the toxicity of the material is moderate to high, a fume hood should be used.

3. Fume hoods should be tested regularly for proper operation. As a minimum standard they should:

   a) Have shut-off valves for services, e.g., gas, air, water, electricity, and vacuum located outside the hood and readily accessible to the operator.
   b) Not be used as storage cupboards.
   c) Be equipped with explosion-proof lighting.
   d) Be constructed or lined with fire-resistant material.
   e) When in use:
      - Maintain a minimum face velocity of 0.5 meters per second with a full sash opening. This can be easily checked, e.g., Do fumes leak into a room (ammonia)? Is a puff of smoke from a cigarette drawn in and up?
      - Have an indicator (light) showing that the fan is operating and when necessary, a positive continuous air flow indicator.
   f) Be designed so that the fan is located at the discharge end of the system inside the ceiling just where it exits from the building (i.e., duct work under negative pressure).

IV. HANDLING GLASSWARE

A. Introduction

The importance of glassware in any laboratory or science work cannot be overestimated. Glass is widely used because it is easy to manipulate into almost any desired shape. Moreover, glass is transparent, relatively insoluble in most reagents, and inexpensive.

It is important that students be properly instructed in the use and care of glassware prior to laboratory work. A very high percentage of laboratory burns and cuts are due to improper handling.

B. General Precautions

1. Laboratory glassware should never be used for eating or drinking.
2. All edges of glass tubing should have fire-polished (beveled) edges to avoid cuts.
3. All glassware should be carefully inspected for cracks or chips before any experiment or demonstration is begun, and the students should be instructed to place cracked, chipped, or otherwise damaged glassware in special marked containers which are situated in designated places. Most damaged glassware will have to be discarded; some minimally chipped pieces may be fire-polished and reused.
4. Sinks or wastepaper baskets should not be used as a disposal place for broken glassware.
5. A whisk broom and dustpan for large pieces or a piece of plasticine or wet cotton for small pieces can be used to pick up broken glass. FINGERS SHOULD NEVER BE USED. A wide area should be swept for any broken particles.
6. All glassware should be stored properly after use. It should not be allowed to accumulate on working surfaces.
7. Glass tubing should be carried and stored vertically.
8. Allowance should be made for the expansion of the contents when sealing glass bottles containing liquid. Bottles should not be filled to the top.
9. The contents of sealed bottles or ampules should be cooled to lower the vapor pressure before they are opened.
10. Specialized apparatus involving glassware should be used in accordance with the manufacturer's specifications.
11. Glassware under pressure or vacuum should be shielded to protect the user in the event of explosion or implosion.
12. If breakage hazard is possible, the glassware should be wrapped, taped, or clamped. The glassware used should be designed to withstand the pressure to which it will be subjected. Often safety surge bottles in line with pressure systems are useful as safeguards. Do <u>not</u> substitute thermos bottles with thin walls for Dewar flasks.
13. Glass containers (terrariums, aquariums) should be placed in an area where they would not likely be bumped or jarred.
14. Aquariums should be emptied with a siphon. Do not move them when they are filled with water.
15. The edges of glass squares may be smoothed with an emery cloth or a wire gauze. Use them as you would a piece of sandpaper, brushing each edge of the glass with four or five strokes.
16. Gloves should be used when handling inferior-grade glass wool.
17. Equipment having glass components should be carefully supported. Glass distillation apparatus, for example, should be supported by several clamps so that stresses caused by its own weight will not be critical. Excessive tightening of the clamp will only bend the clamp or break the glass.

C. Heating Glass

Note: Heated glassware may look cool but can cause burns several minutes after having been removed from the heat source.

1. Wear protective eyewear.
2. Only use Pyrex, Kimex, or a similar glassware with low coefficients of expansion.
3. A safety shield should be used when dangerous, volatile compounds are heated.
4. Glassware heated on an open flame should be positioned on a wire mesh with a ceramic center. Asbestos centered wire gauze should not be used, and the wires in plain gauze may cause the bottom of the container to break due to the production of hot spots.
5. Heat-resistant mats (e.g., floor tiles, ceramic) should be available for hot glass objects taken from a flame. Hot objects should not be placed on the laboratory counter surfaces.
6. Do not allow hot glass to come in contact with cold water.
7. When reactions may produce heat, such as the mixing of acid and water, do not use soft glassware.
8. Use the appropriate tongs for handling hot crucibles or beakers.
   a) The crucibles should be held at the very end of the crucible tongs.
   b) Place the hot crucibles on the base of a ring stand on a heat-resistant pad, or on a clay triangle.
9. Soft glass test tubes should never be used to heat substances. The tube will probably break if it is not thoroughly dry on the outside, or if the flame is concentrated at one spot for any length of time.
10. Hard glass test tubes may be heated directly if the experiment necessitates it. A water bath is preferred.
    a) In heating fluids in test tubes, instruct the pupils to heat from the upper portions of the tube downward and not to allow the heat to concentrate too long in any one spot.
    b) The test tubes should be pointed away from any person.
    c) Spurt caps are available that can be placed over test tube mouths.

D. Cleaning

Glassware should always be cleaned as soon as possible after use because glass is not a completely inert material.

1. Begin with the mildest possible cleaning agent.
2. Avoid using special reagents such as "chromic-sulphuric acid solutions." If such a solution is prepared, on no account should it be stored for occasional use in cleaning glassware. This solution may react with organic matter to produce gases.
3. Use a plastic spatula to remove caked solids from the bottom of a flask. Do not use a glass rod, which may poke a hole in the flask.
4. Make certain that glassware is clean and dry before returning to storage or use.

E. Removing Ground Glass Stoppers

1. Pupils should be instructed not to attempt to remove ground glass stoppers which have become frozen to their reagent bottles, as such attempts frequently result in broken reagent bottles.
2. Often gentle tapping of the frozen stopper with a wooden object or on the side of the bench will free frozen stoppers.
3. If gentle tapping does not work, the instructor may place the bottle in a quantity of absorbant material or in the sink (if the contents are not reactive with water) and apply a stream of hot water to the stopper.
4. While attempting to remove the stopper it may be necessary to use extreme care by wearing goggles, gloves, or protecting the hands with a towel.

F. Glass Tubing, Rods, and Thermometers

1. To reduce the danger of breakage, carry glass tubing, rods, and thermometers vertically, taking special care when turning corners.
2. Glass apparatus should be stored vertically, in special racks. If it is necessary to store it horizontally, the shelf should have a lip to protect against accidental dislodgement.
3. When cutting glass tubing or rods:
   a) Goggles should be worn. Small flakes of glass are produced which are propelled at high speed.
   b) Lay the tubing or rods flat on a table and draw a sharp triangular file or cutting tool across the glass at the point where it is to be cut. This makes a scratch or notch in the glass. Put a few drops of water on the notch or on the file.
   c) Gloves should be worn or a cloth used to cover the tube in the area in which the break is to be made.
   d) Pick up the tubing and hold it with your thumbs behind the notch and the notch away from you.
   e) Snap the tubing sharply, away from your body.
   f) Sweep up any chips on the floor or counter. (This may involve sweeping or cleaning-up a wider area than the inexperienced would anticipate.)
4. The ends of glass tubing are sharp and should not be used without fire-polishing. When fire-polishing:
   a) Wear heat-resistant gloves if appropriate.
   b) Wear goggles.
   c) To smooth the ends, rotate tube in the edge of the flame until the end becomes yellow or orange and the sharp edges melt and become smooth. If this is done correctly, the bore of the tubing will not be changed.
   d) Place the fire-polished tube on heat-resistant material (ceramic, floor tiles) while it cools.
5. When bending glass tubing:
   a) Avoid "kinking" that will obstruct the flow of fluid.
   b) Do not handle glass that has been heated until you have allowed time for cooling. You cannot tell that glass is hot by looking at it.
   c) Check the bent tubing for cracks and discard them in appropriate containers.
6. To insert rods, tubing, and thermometers into stoppers and hoses:
   a) Fire-polish to ensure that the end of the tubing is smooth. The ends can be smoothed with a file or emery cloth, but fire-polishing should be the primary method used.
   b) Be sure that the hole in the rubber stopper is the proper size for the apparatus which is to be inserted.
   c) Use stop-cock grease or glycerin as a lubricant on the ends of the apparatus before insertion into the stoppers. The connection between the glass and the rubber can be prevented from freezing by the use of glycerin.
      Note: Do not use glycerin if the stopper will contact nitric acid. Under these conditions, use water or a soap solution as a lubricant.
   d) Wrap the rod or tubing with several layers of cloth.
   e) Use a glove or a cloth to protect the hand holding the stopper or hose. Glass tubing manipulator (Grip-Safe) is useful for inserting or removing glass tubing. This is available from supply houses.
   f) Hold the wrapped glass as close as possible to, and not more than five centimeters from, the end nearest the rubber stopper.
   g) Always aim the thermometer or tubing away from the palm of the hand which holds the stopper.
   h) Guide the tubing gently to prevent its snapping. Never use excess pressure.
   i) Extra care should be used when inserting a thistle tube into a stopper. Be sure to lubricate the tube first and never hold the tube by the bowl. Put the hand close to the stopper and use a rotating motion.

7. Prompt detachment or removal of apparatus from tubing or stoppers is important. To remove rods and tubing from stoppers and hoses:
   a) Consider discarding frozen stoppers and tubing. Very often, the hazards encountered do not justify keeping them.
   b) Always detach the apparatus before drying can take place if water is a lubricant.
   c) Avoid injury by using a grip-safe, glass tubing manipulator if possible (available from laboratory supply houses). This device is superior to the use of cloth wrapping which may be easily pierced.
   d) Removal may also be facilitated by a wet cork-borer, which will fit over the tubing. Slowly work the borer down through the stopper.
   e) It may be necessary to cut the stopper or hose through to the glass with a sharp, single-edged razor blade or knife. Do not support the stopper against your hand - set it on a counter top.
   f) Difficult removals should not be attempted by inexperienced personnel or students.
   g) Stopper extractors are available from laboratory supply houses.

V. COMPRESSED AIR, GASES, AND AEROSOLS

It is vital that teachers and students exercise caution and prudence in using compressed air, gas, and aerosol supplies in the laboratory. Maltreatment, misuse, and carelessness of these materials can cause serious injury, fires, and explosions, and even death. Following are some basic guidelines in this regard.

A. Compressed Air

1. Any unwanted oil or water should be filtered out from the air compressor before use.
2. Safety goggles should be worn when using compressed air.
3. Air hoses should be kept off the floor to prevent their being damaged or tripped over.
4. The hose should be kept in proper working condition by protecting it from contact with sharp objects, and by coiling it smoothly and using a good support, preferably wood, to hold it.
5. The lowest pressure possible to do the job should always be selected.
   a) A pressure of 270 KPa (40 psi) can rupture an eardrum, blow an eye from its socket, or cause chips and scales from inside the piping to be driven into the face with the force of shrapnel.
   b) 27 KPa (4 psi) against the skin may introduce air bubbles into the bloodstream, with fatal consequences, especially if there are small scratches or punctures of the skin. In addition, the pressure may penetrate deeply resulting in pain and internal hemorrhaging.
6. Compressed air should not be used to dry solvents from the skin since both air and solvent can enter the bloodstream, with the consequences mentioned in 5. above.
7. Compressed air should not be used to remove dust from clothing, objects, or work areas. Use a brush or a vacuum cleaner.
8. A warning label should be affixed on all compressed air supplies to warn students of the hazards of directing compressed air against themselves or others.

B. Compressed Gas Cylinders

The mishandling of gas cylinders due to the user's disregard of safety considerations is responsible for most accidents involving gas cylinders.

1. Physical Hazards

These hazards are associated with the structure of the cylinders and their pressure gauges.

a) The pressure gauges should be inspected before use (see Section C).
b) The outlet should be checked to ensure no obstruction by foreign objects before putting on pressure gauge.
c) Make sure that the cylinder valve can be opened smoothly by hand pressure using the standard wrench.
d) If the valves do not open smoothly, caution should be observed.
   - Do not use excessive leverage or hammers.
   - Return these cylinders unused to the supplier with an explanatory note.
e) Caps should be securely in place for transport or for storage.
f) Cylinders should be securely in an upright position for storage purposes, during transportation, or during use, so that they will not be accidentally dislodged.
g) Specially designed carts should be used if possible for transporting cylinders.
h) Gas cylinders should not be dropped, knocked over, dragged, or banged against each other.

i) Special care should be taken to protect the base of the valve stem, which is the weakest point of a gas cylinder. If the valve is sheared off by forcibly striking a hard surface, the cylinder can become a "jet-propelled missle," capable of piercing even concrete walls.

2. Content Hazards

a) The cylinder wrench should remain attached to the cylinder to facilitate rapid cut-off in an emergency.
b) All cylinders should be plainly labelled in writing according to the contents. Color coding is not a legally recognized means of identification.
c) The cylinder valve should not be opened rapidly. The resulting compression heating in the regulator has caused explosions.
d) Cylinder valves should be tested in an open or well-ventilated area before use in the laboratory.
e) A cylinder should never be left completely empty. There should be a slight positive pressure and a closed valve. This prevents the diffusion of air and other contaminants back into the cylinder, which can result in deterioration of the cylinder or its fittings, or can cause an explosion from the air contaminant - content mixture (especially with flammable gases).
f) Cylinders containing hazardous compounds (such as HCl, SO_2, or propane) should be stored in a well-ventilated place away from heat registers and sunlight.
g) Precautions should be taken against anyone's breathing non-life-supporting gases (e.g., helium, nitrogen, argon), which may cause anoxia followed by unconsciousness.
h) Oil or grease should never be used on oxygen cylinders or lines. Explosion may result.
i) When using oxygen cylinders, remember that the risk of fire increases greatly as the oxygen content of the atmosphere increases, e.g., 21 percent oxygen content - clothing smoulders; 24 percent - clothing burns rapidly.
j) Any blows or bumps to an acetylene or ethyne cylinder should be avoided. A diabatic compression can result, igniting the contents.
k) The valve on a hydrogen cylinder should not be opened too rapidly. Ignition due to static electricity may result.

C. Pressure Gauge Safety

It is important to follow the manufacturer's operational specifications when operating pressure gauges. Failure of a gauge may result in an explosion producing fragments that may cause serious bodily injury.

1. The pressure used should not exceed two-thirds of the maximum pressure provided on the scale, when using steady pressure. Otherwise, the accuracy of the pressure indication and the life expectancy of the elastic chamber may be reduced.
2. The pressure used should not exceed one-half of the maximum pressure provided on the scale, when using fluctuating pressure.
3. The proper gauge for the particular job to be done should always be used.
   a) The maximum pressure that will be required should be determined.
   b) The maximum pressure should be multiplied by 1.5 to obtain a safety factor.
   c) A gauge should be used that has a full scale reading equal to or greater than the safety factor.
4. In addition to the manufacturer's specifications regarding air pressure hazards, extreme caution should be exercised in the mechanical handling of pressure gauges. The hazards inherent in valve stem breakage apply equally to pressure gauge breakage.

D. Aerosols

Aerosols dispensed from pressurized cans also present the dangers of fire, explosion, and dangerous chemical compounds.

1. All instructions on the label of the product should be observed. Many laboratory reagents, such as ninhydrin, are used in an aerosol form and are potentially hazardous.
2. Adequate ventilation, such as a fume chamber, should be used to prevent the inhalation of potentially hazardous aerosols.
3. Aerosols should be stored in a cool, dry place.
4. Aerosol cans should not be punctured.
5. Aerosol cans should be disposed of carefully, away from fire or heat. The aerosol can could explode if heated.

VI. CRYOGENICS

A. Effects on Living Tissue

The extreme cold produced by liquid air, liquid nitrogen, liquid CO_2, and dry ice (solid CO_2), or other cryogenic materials, is a potential hazard.

1. Living tissue may be seriously damaged by contact with cryogenic liquids, their gases, and surfaces.
   a) The resulting frostbite or freezing is comparable in effect to that produced by boiling water or steam.
   b) Cryogenic substances may cause more damage than thermal burns. The damaging effect may extend to the third level of skin.
2. Cryogenic temperatures (-60°C to -270°C) produce some degree of hardening in most materials. Living tissue, a feather, or an iron bar may become so embrittled they will smash into pieces.
   a) Adequate protective apparel should always be worn when handling cryogenic materials:
      - Goggles or a face shield;
      - Pot holders or tongs should be used. Gloves can be frozen to the skin if the cryogenic material enters the glove;
      - Cryogenic materials should never be handled with the bare skin.

B. Pressure Effects

1. Tremendous pressure changes (resulting from a thousandfold increase in volume) and dangerous heat absorption may result when cryogenic liquids vaporize.
2. The necks of containers or baths should not be allowed to become plugged with ice because of the danger of pressure build-up. Vessels may rupture or explode if ice or water plugs the openings.

C. Dry Ice Production

Fire extinguishers should not be used for the production of dry ice, or the extinguisher may be empty when you need it the most. A separate CO_2 cylinder and dry ice making attachment should be used.

VII. MODEL ROCKETRY AND BALLOONS

A. The Air Regulations and Aeronautics Act

In Canada, The Air Regulations and Aeronautics Act, (TP524-1980) defines and regulates the release of balloons, the flying of model aircraft, and the types of model rockets that can be fired, where this may be done, and in what manner.

If science teachers should decide to offer a program in model rocketry, it is vital to become familiar with the terms and regulations of this legislation.

1. "Balloon" means a motorless, lighter-than-air aircraft.

Section 511. No person shall
(a) release an unmanned free balloon; or
(b) operate a manned free balloon
having a gas carrying capacity of more than 115 cubic feet (3 m^3) except with the permission of the Minister and subject to such terms and conditions as may be specified by the Minister.

2. "Aircraft" means any machine capable of deriving support in the atmosphere from the reactions of the air.

Section 512. No person shall fly a model aircraft within 5 miles (8 km) from the centre of any control zone or aerodrome traffic zone, as set out in the Designated Airspace Handbook in a manner that creates or is likely to create a hazard to aircraft.

3. "Rocket" means a projectile containing its own propellant and depending for its flight upon the reaction set up by the release of a continuous jet of rapidly expanding gases.

a) "Model rocket" means a rocket:
- constructed of balsa wood, paper, and plastics and containing no substantial metal parts;
- equipped with model rocket engines that will not generate a total impulse exceeding 80 newton-seconds;
- of a gross weight, including engines, not exceeding 500 grams; and
- equipped with a parachute or other device capable of retarding its descent so that no hazard is created to persons or property on the ground.

b) "Model rocket engine" means a commercially manufactured device designed and used for the propulsion of model rockets.

Section 513. No person shall launch a rocket of any type or kind from any place in Canada without the written authorization of the Minister, except
(a) a model rocket; or
(b) a rocket of a type used in a fireworks display.

Section 514. Notwithstanding paragraph 513 (a), no person shall launch a model rocket
(a) within 5 nautical miles from the centre of any airport;
(b) in any manner that creates or is likely to create a hazard to aircraft;
(c) in any manner that creates or is likely to create a hazard to persons or property on the ground;
(d) into any cloud; and
(e) unless a responsible adult is present to supervise the launching.

B. Associated Hazards and Precautionary Measures

1. Model rocket design and construction should provide for a predictable and accurate flight path. This may be accomplished by attaching surfaces that will provide aerodynamic stability and restoring forces.
2. Rockets must not incorporate any explosive or pyrotechnic warhead or devices capable of producing displays of light, sound, or color or any combination of the above.
3. The model rocket engine must be commercially manufactured and be incapable of spontaneous combustion or ignition: in water, in air, when pressurized, or subjected to sudden movements, forcible striking, or temperatures up to 77°C.
4. The model rocket engine must have a safety release in case the engine casing ruptures, especially if the engine contains some metal parts.
5. The model rocket propellant should:
   a) Be commercially pre-mixed and ready for use;
   b) Not exceed 113 grams (4 ounces) in the engine at the time of launch; and
   c) Provide the total impulse and rearward discharge of gases as a result of combustion completely within the model rocket engine.
6. The launching area should:
   a) Contain 4181 m^2 (5000 square yards);
   b) Approximate a rectangle in shape;
   c) Have no side less than 45.6 m (50 yards);
   d) Be located away from major highways, tall buildings, high voltage power lines, or other obstacles.
7. At the time of launching, the teacher should:
   a) Certify the safety of the rocket(s) and supervise all student launchings;
   b) Warn all personnel in the area that a launching will take place;
   c) Set a launching angle of between 60°-90° from horizontal;
   d) Ascertain that wind speed is less than 12 km/h (20 mph);
   e) Ascertain that visibility is greater than 610 m (2000 feet). (Do not fire the rocket at night or into a cloud);
   f) Ensure that the firing of the rocket is to be achieved by remote electrical means and is completely under the control of the teacher;
   g) Use a device that will provide for a reasonably safe, predictable flight by restricting horizontal motion of the rocket, until sufficient flight velocity has been attained.

Model rockets should be used cautiously. Injuries may result from the hazards associated with fuels and poor directional control.

VIII. HOME CHEMISTRY SETS

The use of home chemistry sets can be very dangerous. Injuries commonly are caused by broken glassware and tubing, sharp hand tools, spilled chemicals, and uncontrolled reactions. Other injuries result from careless pipetting, electrical shocks, hot liquids, careless handling of mechanical equipment, and exposure to vapors or gases.

To minimize these dangers, teachers should ensure that students are aware of the following general precautions:

1. Be aware of the health and safety hazards of all equipment and chemicals used.
2. Be familiar with basic first aid procedures.
3. Work in a properly ventilated area.
4. Use proper methods for the disposal of dangerous waste chemicals and materials.
5. Plan the experiment carefully and never mix chemicals at random.

Teachers should not supply school chemicals and equipment to students for home experimentation.

IX. SCIENCE FAIRS

Science fair rules often ban the use of strong reagents, open flames, explosives, and materials liable to spontaneous combustion, dangerous gases, poisons, pathogenic organisms, and other potentially dangerous or troublesome materials or activities. Teachers should be familiar with and acquaint students with the rules governing any science fair, exhibit, or contest for which projects may be developed.

A. Safety Considerations

1. Teachers should ensure that all projects prepared by students are given a thorough safety check and that students are aware both of the product's specific hazards and the appropriate safety precautions.
2. No dangerous or flammable chemicals should be used in an exhibit.
3. No live poisonous invertebrates should be permitted in exhibits under any circumstances.
4. No experiment should be undertaken that involves anesthetic drugs, surgical procedures, pathogenic organisms, toxicological products, carcinogens, or harmful radiation.
5. The displaying of radioisotopes or compounds containing isotopes should not be allowed. If they are used in experimentation, compliance with standard radiation procedures is necessary.
6. All wiring, switches, and metal parts that carry at least 110-volt currents (radio and electronic apparatus) should be located out of the reach of observers. Open knife switches or doorbell push buttons should not be used on 110-volt circuits. All electrical apparatus should be provided with a suitable cord, switch, and durable attachment, according to standard electrical safety laws. If in doubt, consult a competent electrician.
7. Every effort should be made to provide proper tools to maintain the exhibit and to safeguard the tools and spare parts with tool boxes and locks.
8. Any project which will be viewed by the public should be constructed so that inquisitive observers are protected from possible accidents. These provisions also help to eliminate careless handling by the occasional souvenir hunter.
9. The exhibitor should remain with and maintain the exhibit while the fair is in process.

B. Animals in Science Fairs

Ethical considerations relative to the potential suffering or abuse of living animals should be followed together with considerations for any possible injury or hazard to students and visitors, when projects or displays involving animals are being developed. The following regulations for animal experimentation and safety in science fairs have been developed by the Canadian Council on Animal Care, for use at the Canada Wide Science Fair.

1. Biological experimentation is essential for an understanding of living processes. Such studies should lead to a respect for all living things. Capable students, anxious to pursue a career in biological sciences must receive the necessary encouragement and direction. All aspects of the project must be within the comprehension and capabilities of the student undertaking the study.
2. Lower orders such as bacteria, fungi, protozoa, and insects can reveal much basic biological information. If experiments are to be conducted on living subjects for Science Fair projects, then only lower orders of life may be used.
3. Vertebrate animals are not to be used in experiments for project for science fairs, with the following exceptions:
   a) Observations of normal living patterns of wild animals in the free living state or in zoological parks, gardens, or aquaria.

b) Observations of normal living patterns of pets, fish, or domestic animals.

4. No living vertebrate animal shall be displayed in exhibits in science fairs.
5. Cells such as red blood cells, other tissue cells, plasma, or serum purchased or acquired from biological supply houses or research facilities may be used in science fair projects.
6. Observational type studies on only chicken egg embryos may be used in science fair projects. If normal egg embryos are to be hatched, satisfactory humane considerations must be made for disposal of the chicks. If such arrangements cannot be made then the chicken embryos must be destroyed on the nineteenth day of incubation. No eggs capable of hatching may be exhibited in science fairs.
7. All experiments shall be carried out under the supervision of a competent science teacher. It shall be the responsibility of the qualified science teacher to ensure the student has the necessary comprehension for the study to be undertaken. Whenever possible, specifically qualified experts in the field shall be consulted.
8. Micro-organism safety and bio-hazards:
   a) The following hazardous biological materials may not be displayed at the science fair:
      - Radioisotopes or compounds containing isotopes
      - Biological toxins
      - Micro-organisms pathogenic to animals
      - Cells or tissues infected with animal viruses
   b) All cultures placed on exhibition should be sealed.
   c) Experimentation involving hazardous materials must be carried out under controlled laboratory conditions and supervision.

   Note: The use of mixed cultures obtained from the environment, e.g., soils, mouth swabs, fingers, etc., are acceptable for experimentation and display.

In general, projects requiring the use or display of live animals must have the approval of the Youth Science Foundation. For information write to:

Canadian Council on Animal Care
Suite 1105
151 Slater Street
Ottawa, Ontario
K1P 5H3

Youth Science Foundation
Animal Care Committee
Room 302
151 Slater Street
Ottawa, Ontario
K1P 5H3

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X. CHEMISTRY

A. Introduction

The chemistry laboratory is an area containing many potential hazards, and careful attention must continually be given to the use and storage of both chemicals and laboratory apparatus to ensure that accidents including fires or explosions do not occur.

The following rather detailed information has been compiled for the guidance of teachers concerning potential hazards and recommended operating procedures in a chemistry laboratory and to act as a ready reference source. In addition to the following guidelines, teachers are referred to the information on general safety, accident prevention, and first aid in the general publication on safety.

B. Adequate Facilities and Equipment

1. In instances where new laboratories are being planned, educators should ensure that the relevant authorities are apprised of the space and facilities requirements necessary for the safe, efficient, and adequate performance of chemistry experiments by students.
2. If classrooms are to be used as laboratories, it may not be feasible to conduct some recommended experiments.
3. Good laboratory design features should include:
   a) wide aisles
   b) flooring which will neither be slippery nor transmit an electrical shock when wet
   c) sturdy furniture with round corners and edges
   d) ground fault interrupters and non-sparking switches
   e) master shut-off switches and valves which are easily accessible to the teacher and are clearly marked
   f) two unobstructed exits per laboratory
   g) fume chamber that maintains a minimum face velocity of .5 meters per second with a full sash opening
   h) ventilation should be maintained at a rate to ensure that the air pressure in the laboratory is slightly negative with reference to adjacent halls and rooms not used as laboratories
   i) sinks with hand washing facilities and eye wash stations
   j) adequate number of electrical outlets, away from water sources
4. Chemical laboratories should have:
   a) stocked first aid kit
   b) adequate equipment and apparel for the personal protection of all students and teachers (goggles, laboratory coats, gloves, hair ties, etc.)
   c) appropriate, labelled containers, shelves, and cabinets for the safe storage of all laboratory materials and apparatus
   d) separately labelled containers for waste and broken materials and apparatus
   e) appropriate fire extinguishers, fire blanket, and sand pails, and chemicals or kits to deal with spills
   f) easily accessible clean-up equipment
   g) alcohol or gas burners of metal construction
   h) additional apparatus and materials as appropriate to the nature of the laboratory exercises undertaken (see the preceding chapters of this manual for specific details)
5. Desirable features for a storage room are:
   a) construction of fire-proof materials
   b) appropriate and immediately accessible fire monitoring and protective devices, including a sprinkler system, heat and/or a smoke detector, fire extinguishers, emergency source of light, and chemical spill clean-up materials

c) direct ventilation to the outside (fans, fume chambers, windows).
d) adequate lighting (including an emergency source) and switches and light fixtures of the explosion-proof variety.
e) provision for a drain in the floor and a water tap with a hose attached so that spilled materials can be flushed away.
f) adequate floor space, with a smooth, chemically resistant floor so that spilled materials can be easily removed.
g) two well-marked exits.
h) security provisions, including locked cupboards and a sturdy door which is always locked on the outside, crash bar on the inside.
i) shelving that is permanently fixed and which has rimguard shelves to reduce the danger of glass equipment jarring off shelves and breaking on the floor.
j) vented metal cabinets, appropriate containers, or fire resistant cabinets which may be locked for all readily combustible materials.

7. Storage room maintenance should emphasize:
a) cleanliness and order, including the complete closing of all containers when not in use.
b) inventory control (labelling, dating on receipt, chemical audits, disposal, locked cupboards, proper storage of chemicals).
c) only authorized use of and entry to the storerooms; place prominent signs on the storeroom doors regarding admission.
d) no ignition sources, such as open flames, direct sunlight, high temperature, and inadequate electrical wiring.
e) safe accessibility to all supplies. When shelving cannot be safely reached from a standing position, a step-up system must be available.
f) careful storage of glassware to prevent breakage (heavier pieces on lower shelves, longer pieces behind smaller pieces on the shelf, and glass tubing and rods will be supported in a glass storage rack).
g) no protruding apparatus or materials beyond the shelf edge.
h) regular checking of storage refrigerators, and prohibition of food in the refrigerator.
i) storage of gas cylinders in an upright position, secured above their centre of gravity to prevent dislodging, with their main valves closed, and away from heat sources and hazardous chemicals.
j) storage of stock chemicals should be separate from equipment, if possible. This is particularly true for delicate apparatus or items which corrode easily.
k) the discarding of obsolete items, unlabelled or illegibly labelled containers, and any chemicals that show signs of decomposition; securely close all stored materials.
l) the placement of a protective tray (e.g., polyethylene) between all acids and bases and their supporting wooden shelf.
m) storage of incompatible chemicals away from each other. To minimize chemical hazards, group according to the following: dry chemicals - may be stored alphabetically, most dry chemicals stored above wet chemicals;[1] acids and bases (segregated from each other); flammable liquids; miscellaneous liquids.
n) storage of flammable volatile liquids in tightly stoppered safety cans with springloaded covers and in as cool a place as possible.
o) storage of organic chemicals in amber bottles in closed cabinets to prevent exposure to heat sources.

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[1] Lithium, sodium, potassium, calcium carbide, and other water sensitive chemicals may be stored in the same area as the dry chemicals but kept separately.

C. Laboratory Techniques

It is important that the teacher be fully aware both of the safest methods of conducting laboratory exercises and the hazards involved in failing to do so, as well as the guidelines for teacher and student responsibility in chapter 1.

The following additional suggestions are provided for consideration:

1. The first laboratory session(s) should be devoted to stressing safe laboratory techniques, including, for example, the use of protective apparel and equipment, proper methods of handling and dispensing hazardous reagents, fire, and first aid procedures, and safe means of storing and/or dispensing of chemicals and apparatus at the end of the experiment.
2. Each experiment should be approved by the instructor and special safety reminders for <u>each</u> experiment should be reviewed orally and in writing before the laboratory session is to begin.
3. It may be advisable that only the minimum equipment and chemicals required should be available to the students to avoid waste, contamination, and potential hazard.
4. The labels of all containers should be checked when the chemicals are selected and again before their use in the experiment.
5. Eating and drinking should not be permitted in the laboratory.
6. If objectionable gases may be given off during an experiment, the operation should be performed in a fume hood.
7. Students should be seated as far away from a demonstration table as necessary to avoid the possibility of injury through the spattering of chemicals, the inhalation of fumes, or fire from an overturned burner.
8. Demonstrations involving explosive mixtures must be arranged in a manner which shields both students and teachers from the results of an explosion.
9. Students should be directed not to taste a chemical unless instructed to do so, and to smell a chemical, when so instructed, by <u>gently</u> fanning the vapors toward the face.
10. In obtaining liquid reagents, students should be reminded to pour the reagent slowly from the containers into a clean beaker or test tube, using a pouring rod. The container into which the liquid is being poured should rest firmly on the laboratory table or in a rack - do not hold it in the hand.
11. Pipetting by mouth is hazardous and unsanitary. A cotton plug in the upper end of the pipette offers no protection. Pipettes, however, may be used safely with a rubber bulb.
12. A test tube is much like a gun. Teach the pupil never to point the opening at another pupil, to look down into a test tube containing a reagent or hot water, or to heat a test tube closed with a solid stopper.
13. Activities involving the reduction of pressure should contain a safety device for equalizing the pressure when the experiment is completed.
14. Check gas generators carefully to be certain that there is no point at which the passage of the gas is blocked. Blowing through the delivery tube will indicate whether there is blockage.
15. In collecting gas by water deplacement, the delivery tube should be removed from the generating flask or from under the water to prevent water from being forced back into the hot generator.
16. Inadvertent burns may be avoided if the pupil is taught to test the questionable beaker, ring stand, wire gauze, or other pieces of apparatus by bringing the BACK of the hand near the object, thus measuring its heat radiation.
17. Special beaker tongs should be available for handling hot solutions. Wrapping the hot beaker with a towel or other cloth is not advisable. Lacking beaker tongs, heat resistant gloves should be worn.

18. Spattering and sputtering almost always occur when solutions are evaporated to dryness. Many students are reluctant to cover the evaporating dish with a watchglass because the cover slows the evaporation. Inverting a 600 ml beaker over the evaporating dish in the early stages of the process will protect the student without materially slowing the evaporation.
19. When stones, glass beads, or other materials used to control boiling are added to liquids, they should be added when the liquid is well below its boiling point, preferably before heating is started.
20. If a Bunsen burner "strikes back," immediately turn off the gas. Adjust the burner in order to admit less air and relight, holding the match to the side and above the barrel of the burner, not directly above. Spark lighters are preferred.
21. Instructors, students, and storeroom assistants should wash their hands after each possible contamination.

D. Some Specific Hazards

Certain chemicals used in school laboratories may present potential hazards in their use or storage. Some of the more common hazardous chemicals and laboratory techniques are discussed below. This list is not all-inclusive. The teacher should have appropriate reference material available.

1. Mercury should be handled so that it does not come into contact with the skin and that spilled material may be easily collected (see pages 47-49 for suggestions on handling spills).
2. Special precautions must be observed when heating mercuric oxide.
   a) Danger may be reduced to a safe level by placing a loose plug of pyrex glass wool (not absorbent cotton or other combustible material) in the mouth of the test tube.
   b) A fume hood should be used.
3. Never cork a bottle containing dry ice, as liquid air and dry ice dramatically increase in volume on vaporization with resulting increases in pressure.
4. Heating oils or solids such as paraffin wax may produce flammable vapors.
5. Metal oxide particles falling from metal screw caps may catalyze various decomposition reactions (e.g., peroxides formed in ethers may decompose explosively).
6. White (yellow) phosphorus must be cut only under water. If cut in the open air, the friction may be sufficient to ignite the material with very serious results. Use red phosphorus in place of white (yellow) phosphorus whenever possible. Remnants of phosphorus should be completely burned in the fume-hood before depositing residues in the waste jar.
7. Discard ammoniacal silver solutions immediately after use, otherwise explosive imides or nitrides (fulminating silver) may be formed.
8. Use sulfide producing chemicals which are available as H_2S substitutes (HAITCH-2-S) in place of hydrogen sulfide, which is poisonous.
9. Benzoyl peroxide is hazardous; the friction produced by opening the screw cap has caused explosions. Stabilizer blended commercial solutions are available in hobby shops (blended in phthalate esteroil).
10. Hydrogen generators can explode before all air has been expelled from the system. The following precautions should be taken:
    a) Wrap the generator securely with appropriate materials (cloth, towel, tape) prior to starting the experiment.
    b) Use appropriate safety sheilds.
    c) Open flames should be prohibited during production of hydrogen.
    d) Dismantle the generator before testing.
    e) Flame testing of only small samples of H_2 is recommended.
11. During the laboratory preparation of oxygen by the heating of potassium chlorate and the downward displacement of water always be alert to the following:

a) Hands inadvertently placed (e.g., burner adjustment) under a test tube of decomposing potassium chlorate may be badly burned by the boiling compound (400°C) if the test tube breaks.
b) If the potassium chlorate is contaminated with organic matter (e.g., wood splint, charcoal) an explosion may result.
c) If manganese dioxide is used as a catalyst rapid heating may cause an explosion because oxygen is produced too rapidly.
d) Always remove the delivery tube from the pneumatic trough before removing the heat. If the heat is removed first, the gases cool in the generator assembly creating a reduced pressure area, air pressure forces water from the pneumatic trough into the delivery tube and then onto the hot potassium chlorate in the test tube, and the steam produced will shatter the test tube explosively.
e) Do not reheat the generator after allowing it to cool.
f) Potassium chlorate often detonates when ground with mortar and pestle.

12. Do not store oxidants and reductants near or above one another. An explosion will result if potassium chlorate is mistakenly heated with charcoal instead of manganese dioxide. A spill may accidentally mix them.
13. Ion-exchange resins should be prepared as slurries in an open container before loading the column. Swelling resins have been known to shatter glass ion-exchange columns.

E. Labels and Warning Signs

In the past twenty years, much attention has been given to the provision of protective labels on home chemical products. It is important to realize that chemicals in the science laboratory are at least as dangerous and usually more so. Therefore the labelling and dating of all containers when chemicals are received or prepared is essential for safe operations. A number of symbol systems have been developed to supplement the basic labels. For example, radioactive material requires special labelling as outlined by the Atomic Energy Commission. Some considerations and precautions in labelling are outlined in the following pages.

1. Label Information

a) When chemicals are purchased their labels should contain the following information:
NAME - chemical and common
FORMULA
MANUFACTURER
LOT NUMBER
TYPE OF HAZARD - explosive, flammable, irritant, corrosive, radioactive, biohazard, oxidizer, organic peroxide, poison, poison irritant
DEGREE OF HAZARD - Danger - highest degree of hazard; Caution - lowest degree of hazard
STATEMENT OF HAZARD - indicates each type of hazard present, along with the handling of the chemical
PRECAUTIONARY MEASURES - instructions on preventing injuries from the hazard(s)
FIRST AID INSTRUCTION FOR CONTRACTED EXPOSURE

b) 704M System
The National Fire Protection Association in the United States has developed a second labelling system for new containers after the transfer of chemicals, and for chemicals produced by dilution, mixing, and preparation during experiments.

A diamond-shaped diagram is used with the diamond divided into four parts, and each section is color coded; blue - health hazard; red -

flammability; yellow - reactivity; white - "special."

Numbers which range from 0 (no hazard) to 4 (maximum hazard) are used to indicate the degree of severity of health hazard, fire hazard, and chemical reactivity. The numbers are placed in the squares.

This numeral-color system is intended to give the observer information about potential hazards quickly.

Further information on this system and blank 704M labels may be purchased from safety supply houses or from the National Fire Protection Association, 470 Atlantic Avenue, Boston, Massachusetts 02210, U. S. A.

c) Additional Precautions
The shelf-life and date of acquisition should be noted as certain chemicals decompose over time and the container may therefore no longer contain what the label says.

Labels should have a protective coating and should be written in "permanent" blue-black ink, India ink, or be typewritten.

Chemicals and solvents with a hazard rating of 2 or higher in any category, should be well labelled, carefully controlled, and discretely used.

F. Flammable and Combustible Liquids and Solids

1. Definitions

Flammable Solid	- Any substance other than explosives, which is likely to cause fire by self-ignition.
Flammable Liquid	- A liquid with a flash point below 37.8°C (100°F).
Combustible Liquid	- A liquid having a flash point above 37.8°C (100°F) and below 93.3°C (200°F).
Flash Point	- The lowest temperature at which a flammable vapor-air mixture above the liquid will ignite when the ignition source is introduced.

Flash point data can be classified as follows:

DANGEROUS - less than or equal to 23°C (73°F)
WARNING - 23°C (73°F) to 37.8°C (100°F)
CAUTION - 37.8°C (100°F) to 93.3°C (200°F)
MODERATELY COMBUSTIBLE - 93.3°C (200°F) to 815.6°C (1500°F)
NON-COMBUSTIBLE - greater than 815.6°C (1500°F)

Flammable solids generally self-ignite from sparks, friction, or flames. Flammable liquids ignite when they are mixed with air in an enclosed space and exposed to an ignition source.

2. General Rules for Storage and Handling

a) Where possible, quantities of flammable and combustible liquids on hand should not exceed one year's use.
b) Containers used for storage of flammable and combustible liquids in open laboratory areas should not exceed 4.5 litres capacity.
c) Where the volume of the container exceeds the two litre capacity and where the content is not analytical grade, the contents in open laboratory areas should be stored in approved safety containers.

d) Quantities of flammable or combustible liquids in open laboratory areas should be restricted to the amount essential for the operation but should not exceed 45 litres flammable and 225 litres combustible liquids (Manitoba Fire Code 4263).
e) Where the volume of the container exceeds the two litre capacity and where the content is not analytical grade, the contents in open laboratory areas should be stored in approved safety containers.
f) Flammable liquids should not be transferred or heated near an open flame or other sources of ignition.
g) Violent explosions have resulted from the placing of volatile flammable liquids (either impregnated in material or in bottles) in refrigerators with internal thermostatic controls which spark in operation. Explosion safe refrigerators should be used.
h) Low flash-point liquids should not be heated or distilled over a naked flame. In such cases a water bath or heating mantle should be used.
i) Some liquids, for example, carbon disulphide, will ignite on contact with a hot surface.
j) In carrying out distillations the rate of heating must be such that liquid does not accumulate in the condenser, otherwise it may be blown out and set alight by a distant flame. All glassware must be carefully examined for flaws and illfitting joints before commencing any operation.
k) Alkali metals, such as metallic lithium, sodium, and potassium, if it is necessary to keep them at all, must be kept submerged in a suitable petroleum oil, and containers (glass or stoneware jars) should be embedded in sand.
   - These chemicals should not be kept in large quantities and any in excess of immediate requirements in the laboratory should be kept in a fire-resistant area.
   - Fires involving small quantities of these substances should be extinguished by either covering them with sand or by the use of a Class "D" fire extinguisher.
   - NOTE: Class A, B, or C fire extinguishers are not to be used for metallic fires.
l) Careless disposal of phosphorus residues and pieces of hot charcoal has occasionally led to fires.
   - Hot charcoal should be placed in a non-combustible receptacle until cool, or cooled under the tap.
m) Strong oxidizing agents such as chlorates, perchlorates, and nitric acid and nitrates, permanganates, and peroxides should be stored so that they cannot be accidentally mixed with readily oxidizable materials such as organic matter, charcoal, or sulphur. They should never be placed on paper or on a wooden surface.
n) Flammable solvents must be isolated from:
   - Ignition sources (e.g., lit burner).
   - Explosives (e.g., trinitrobenzene).
   - Oxidizers (e.g., sodium peroxide).
   - Materials that liberate heat when they react with air or moisture (e.g., sodium).
   - Materials that are capable of spontaneous heating (e.g., potassium chlorate).

3. Flammable Materials Storage Containers

The heating of flammable materials such as organic solvents, alcohols, and hexane should be carried out on a hot plate or water bath and not over an open flame. A partial list of flammable chemicals is given below with the appropriate storage container for large quantities indicated as well.

a) Flammable Liquids	Storage Container
*Acetone	Tin Can
*Alcohol, denatured	Tin Can

*Alcohol, Ethyl	Tin Can
*Alcohol, Methyl	Tin Can
Aldehyde, Ethyl	Glass Bottle
Amyl Acetate	Glass Bottle
Amyl Alcohol	Glass Bottle
Coal Tar Oils	Tin Can
Crude Petroleum	Tin Can
Glycerine	Glass Bottle
Ether, Ethyl	Tin Can
*Hexane	Tin Can
Kerosene	Tin Can
Turpentine	Tin Can
*Toluol or Toluene	Tin Can
Varnishes, Lacquers	Tin Can
Wood Cresote	Tin Can
*Xylol or Xylene	Tin Can

*NOTE: When possible, safety cans with snap back lids and flash arrestors should be used for storage and dispensing of flammable liquids.

b) Combustible Solids	Storage Container
Camphor	Glass Bottle
Cotton absorbent	Paper Box
Cotton batting	Paper Box
Lampblack	Tin Can
Metallic Magnesium (strip and powder)	Glass Bottle
Phosphorus white	Under water in glass bottle surrounded by sand
Phosphorus red	Glass Bottle
Pitch	Tin Can
Pulverized Charcoal	Tin Can
Resins	Tin Can
Rosin	Glass Bottle
Sulphur	Tin Can
Tar	Tin Can

G. Explosive Materials

1. There are three classes of explosives:
   Class A - major explosive hazard
   Class B - combustion or projection hazard
   Class C - principally a fire hazard - may explode under unusual conditions
   In an explosive condition, the substances may be present as gas, small droplets of liquid, or even as dust.

2. Many exothermic reactions with gaseous or finely divided reactants or products may explode violently. With such mixtures the rate of reaction depends upon the composition of the mixture. The rate reaches a maximum for a definite composition.

   Unstable compounds may decompose explosively. Many of these are familiar to you, being routinely stocked in school chemistry laboratories. All substances of this type require careful handling. Among the great many combinations which may cause explosions, the most likely to occur accidentally in school laboratories are to be found in the listing of incompatible chemicals on page 45.

a) The lower explosion limit for dust (grain, coal, etc.) is about 50 mg/L and depends more on particle size than on the type of material. The explosive nature of finely divided or powdered metals is primarily due to their fast exothermic reaction with oxygen and in some cases even with nitrogen (e.g., Mg, Ti).
b) Since temperature and humidity as well as other factors may affect the explosive limits, it is usually advisable to apply a safety factor of 2 or 3 when working with organic substances. Thus, for example, when working with methane, it is desirable not to have the concentration of methane to exceed 2 to 3% in air though the explosive limit is 5%.
c) Good ventilation is essential if fires or explosions are to be avoided.

H. Reactive Chemicals (Oxidizing and Reducing Agents)

The careful handling and storage of these substances is essential to prevent accidents and injury.

1. General Precautions

a) Oxidizing and reducing substances should be isolated from each other and separate reactive chemicals from toxicants, corrosive, flammable solvents, and organic materials.
b) Oxidizing agents are corrosive to the skin. Copious water washing is necessary if contact is made.
c) Buildings should be fireproof and provided with an automatic sprinkler system except where materials are water sensitive. Oxidizers provide their own oxygen for combustion and many normal fire-fighting procedures are not particularly effective.
d) Strong oxidizing agents, such as chlorates, perchlorates, and perchloric acid, nitric acid, and nitrates, permanganates, and peroxides should be stored so that they cannot accidentally be mixed with readily oxidizable materials such as organic matter, charcoal, or sulphur.
e) Oxidizing agents should never be placed on a paper or wooden surface.
f) Containers should be highly sealed and kept in a cool, dry, well-ventilated area away from direct sunlight. Protect from excremes of temperature and rapid temperature changes.
g) Most peroxides and other oxidizing agents should be stored in glass bottles. Silver nitrate should be kept in a brown bottle; potassium chlorate, potassium nitrate, potassium permanganate, sodium chlorate, and sodium nitrate could alternatively be stored in a tin can.

2. Perchloric Acid

a) Perchloric acid is especially hazardous. Its fumes and liquid burn eyes severely.
b) At temperatures of 160^{o}C, it is a strong dehydrating agent in concentrated or in vapor form.
c) Sensitive explosive mixtures may form with organic materials even in solutions of 60-72% perchloric acid.
d) Specially designed perchloric acid fume chambers are required if this acid is to be used.
e) Strong dehydrating agents may produce the anhydrous acid which decomposes at room temperature and explodes on contact with most organic mixtures.
f) For disposal of perchloric acid, contact Department of Consumer and Corporate Affairs and Environment, Environmental Management Division, Province of Manitoba.

3. Chromates and CrO_3

a) Should not be used for cleaning solutions.

b) When dropped on the skin they can cause long lasting ulcers, not ordinary burns.
c) Some are recognized carcinogens.
d) Persons handling them should wear gloves and eye protection and work in a fume chamber.
e) They are very harmful to the lungs if the dust is inhaled, to the eyes, and to the skin upon contact.

4. Iodine

a) Iodine is a strong oxidizing agent.
b) The solid should not be put in contact with any organic solid, liquid, gas, or vapor.
c) Do not touch solid iodine with your bare skin. The solid can cause severe skin burns and contact may result in skin ulcers.
d) Iodine vapors should not be inhaled. The vapor is highly irritating to the nose, throat, and lungs.
e) All laboratory operations that may result in the generation of iodine vapors should be conducted in the fume hood.
f) Gloves should be worn and spatulas or tongs used when handling the solid.

5. Bromine and Bromine Water

a) The vapor is extremely irritating to the eyes, lungs, and skin. If swallowed, it is poisonous and extremely corrosive to the skin.
b) Gloves and eye protection should be worn and it should be handled in a fume cupboard.
c) The outside of the bottle should be washed after use.
d) Do not pour from a bottle. Use a pipette with a bulb.
e) The room must be evacuated if there is a spillage.

6. Hydrogen Peroxide - 35% Solution (100 Volume)

a) Solutions above 50% may ignite combustible materials without an ignition source.
b) Solutions below 30% decompose releasing oxygen.
c) Concentrations above 30% are one of the strongest oxidizing agents, exceeded only by ozone and fluorine and one or two less common substances.
d) Gloves and eye protection should be worn and it should be used in a well-ventilated area.
e) If above 30%, it is especially corrosive to the skin and can cause blindness if splashed into the eyes.

7. Sodium Peroxide

The precautions are the same as with hydrogen peroxide.

8. Benzoyl Peroxide

a) Benzoyl peroxide, if used at all, should only be purchased in small quantities and, once opened, checked regularly, as it is explosive when dry.
b) It can be stored in a closed vessel maintained at high humidity, e.g., a dessicator with water in the lower compartment.

9. Organic Peroxides

a) These are among the most hazardous chemicals found in laboratories.
b) They are sensitive to shocks, sparks, heat friction, and light, as well as to strong oxidizing and reducing agents.

I. Water- or Moist-Air-Sensitive Chemicals

The chemicals which have affinity for water (dehydrating agents) may cause severe burns when in contact with the skin. Important dehydrating agents used in the schools include concentrated sulphuric acid, sodium hydroxide, calcium oxide, and glacial acetic acid.

1. General Precautions

a) Chemicals which change on exposure to air should be bought in small amounts. Examples are phosphorus pentachloride, aluminum chloride, and silicon tetrachloride.
b) Explosions can result from tightly stoppered bottles which contain these substances. After such bottles have been opened they should be kept loosely stoppered for a few days in a dessicator. The lid should then be sealed with silicon grease and tightened before storage.
c) Care should be taken that lithium, sodium, potassium, and calcium are not stored above water solutions or vessels containing water.
d) Lithium, sodium, and potassium must be kept under kerosene and stored in glass stoppered bottles, protected from fire and impact by sand, on the bottom of a locked cupboard.
   - Check the kerosene levels regularly.
   - The covering liquid must be free of moisture and halogenated hydrocarbons.
e) Keep all containers away from direct sunlight or heat. Store in a cool, dry, well-ventilated area to protect from flammable gas build-up.
f) The following warning label (in red) should be placed on containers of calcium carbide, metallic potassium, metallic sodium, metallic lithium, calcium oxide, and sulphuric acid: "IN CASE OF FIRE DO NOT USE WATER."
g) Old samples of potassium may form a yellow superoxide which is explosive.

J. Corrosive Chemicals

Corrosive chemicals are those substances that by direct chemical action are corrosive to metal or injurious to body tissue.

Some typical corrosives that may be encountered in school laboratories are:

Acids	Strong Bases	Other
Sulphuric (H_2SO_4)	Ammonium Hydroxide (NH_4OH)	Bromine (Br_2)
Acetic (CH_3COOH)	Sodium Hydroxide (N_2OH)	Phosphorus (P_4)
Nitric (HNO_3)	Potassium Hydroxide (KOH)	
Hydrochloric (HCl)		

1. Precautions for Storing Corrosive Chemicals

a) Should be stored in well-ventilated, cool, dry area.
b) Should be kept away from sunlight.
c) Should be protected from rapid temperature changes.
d) Should be kept from other reactive chemicals, combustibles, toxicants, organics, and other potential hazards such as other corrosives' fumes.
e) Acids and bases should be segregated.
f) Should be isolated from uncoated structural materials.
g) Water spray devices such as an automatic sprinkler system should be available.
h) Fire-fighting equipment should be immediately available.

i) Avoid spilling concentrated alkali solutions on the floor. They will make the floor slippery. Follow the appropriate, additional safety precautions for specific acids, depending on whether they are also oxidizing agents, dehydrating agents, and so on. Read the product labels carefully for pertinent information.
j) Wear protective equipment (e.g., goggles, face shield, gloves, etc.), when handling these materials.
k) If the danger of inhaling corrosive fumes exists, use a proper fume chamber. If one is not available, wear suitable respiratory protection.
l) Immediate first aid in the event of damage to skin, must include flushing with large amounts of water. Then seek medical attention.

2. Corrosive Chemicals Storage Containers

a) Phosphorus must be kept under water (above $0^{\circ}C$) and in a glass stoppered bottle.
- As a further precaution, this container may be placed in a metal container.
- The container should be inspected frequently for water leekage or deficiencies.
- Phosphorus should be stored where there is a minimum chance for accidents.

b) Calcium carbide and sodium peroxide should be kept in air-tight containers and not stored near water.
- Do not keep a large supply.

c) Chromic acid, glacial acetic acid, hydrochloric acid, potassium hydroxide, sodium hydroxide, and sulphuric acid should be stored in glass bottles and be well-labelled.

K. Toxic Chemicals

Those materials which will cause damage to the human organism are referred to as toxic. A poison is a substance that is toxic at low levels. Poisonous substances commonly found in school laboratories include practically all salts of heavy metals (e.g., mercury, lead, silver) and most gases which can be smelled.

1. Routes of Entry to the Body

a) Sensory effects such as pain or smell may be useful in revealing the presence of many toxicants. However, olfactory fatigue may prevent detection of many toxic chemicals, while the threshold of odor is higher than the safe level for many other toxins. Thus sensory warning should not be relied on as a first defence.
b) Inhalation of toxic fumes or dust by nose or mouth is a potential hazard as they may be rapidly absorbed into the blood stream.
c) Most substances are harmful when in contact with the eyes. Resulting damage may include loss or impairment of vision, pain, and irritation.
d) Skin contact with toxicants through the sweat glands, hair follicles, or open wounds may result in problems ranging from skin irritation to absorption through the skin with accompanying systematic effects.
e) Contact between the following toxic materials and the skin should be avoided:
Acetic Acid (conc.), Bromine (liquid), Carbon Tetrachloride, Chromates, Formic Acid, Hydrochloric Acid, Mercury, Nitric Acid, Phenols, Phosphoric Acid (Hot Concentrated), Potassium Hydroxide (solid and in solution), Sodium Hydroxide (solid and in solution), Sulfuric Acid.
The above are only partial lists of toxic materials.
f) Ingestion and injection of toxins are sources of hazard primarily resulting from disregard of safe handling practices, and subsequent accidents.

2. Precautions for Handling and Storage

a) Handling
- Containers should be sealed as tightly as possible to prevent toxicants being released to the environment.
- Toxicants should not be flushed down a drain.
- Containers should be inspected periodically for deficiencies.
- Contact of toxicants with clothing and shoes should be avoided.
- Localization of toxic concentrations increases when clothing and shoes are contaminated.
- Protective clothing should be used when handling toxic chemicals.
- Hands should be routinely washed after each laboratory period.
- Eating or smoking in a laboratory should be prohibited.
- All toxicants should be protected from sources of reaction.

b) Storage. Toxicants should be -
- Stored in cool, dry, well-ventilated areas.
- Isolated from heat, moisture, and sunlight.
- Protected from acid fume contamination.
- Protected from fire hazards.

L. Incompatible Chemicals

Reagents in many science laboratories are stored alphabetically on shelves. Although this system facilitates storage and retrieval, it is hazardous because incompatible chemicals may be stored close to one another. Teachers should be alert to this potential hazard.

1. Handling and Storage

a) Chemicals should be separated from one another according to their hazard potential. Additional rooms and cabinets may not, however, be required. If facilities are inadequate, chemicals can be stored on separate shelves or on the other side of the room.

b) Incompatible substances may become hazardous and even explosive when mixed in spite of being harmless individually. During experiments, these incompatible chemical combinations must be considered.

2. Incompatible Chemicals Chart

Examples of incompatible chemicals which may be encountered in a school laboratory are shown below.

Chemical	Should Not Come in Contact With . . .
Acetic acid	Nitric acid, chromic acid, peroxides, permanganates, ethylene glycol, hydroxyl compounds.
Acetone	Concentrated nitric and sulfuric acid mixtures.
Alkali metals, e.g., sodium or potassium	Carbon dioxide, carbon tetrachloride, chloroform, water, inorganic acids.
Alkaline metals, e.g., powdered aluminum or magnesium	Carbon tetrachloride or other clorinated hydrocarbons, halogens, carbon dioxide, organic acid.
Ammonium hydroxide	Mercury, chlorine, calcium hypochlorite, iodine, bromine, aluminum.
Ammonium nitrate	Acids, inflammable liquids, metal powders, sulfur, chlorates, any finely divided organic or combustible substance.
Bromine, chlorine	Ammonia, petroleum gases, hydrogen, sodium, benzene, finely divided metals, turpentine, other hydrocarbons.

Chemical	Should Not Come in Contact With . . .
Calcium carbide	Water, alcohol.
Calcium oxide	Water.
Carbon, activated	Calcium hypochlorite.
Chlorates	Ammonium salts, acids, metal powders, sulfur, any finely divided organic or combustible substance.
Chromic VI acid and Chromium trioxide	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general, paper, or cellulose.
Chlorine	See bromine.
Copper	Acetylene, hydrogen peroxide, nitric acid.
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, the halogens.
Fluorine	Isolate from everything.
Hydrocarbons (butane, propane, benzene, turpentine, etc.)	Fluorine, chlorine, bromine, chromic acid.
Hydrogen fluoride	Ammonia, aqueous or anhydrous.
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, combustible materials.
Hydrogen sulfide	Oxidizing gases, fuming nitric acid.
Iodine	Acetylene, ammonia, hydrogen, aluminum.
Mercuric oxide	Sulfur.
Mercury	Acetylene, ammonia.
Nitric acid (conc.)	Acetic acid, acetone, alcohol, hydrogen sulfide, inflammable liquids and gases, zinc and magnesium, copper, glycerin, chromic acid.
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, or gases.
Oxalic acid	Silver, mercury.
Perchloric acid	Acids (organic or mineral), acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils, organic amines, or anti-oxidants.
Peroxide	Magnesium, zinc or aluminum, filter paper, or other organic substances.
Phosphorus, red	Nitric acid, a nitrate, or a chlorate, carbon disulphide.
Potassium chlorate	Sulfuric and other acids, any organic substance.
Potassium permanganate	Sulfuric acid, glycerin, ethylene glycol, organic acids, benzaldehyde.
Silver	Acetylene, oxalic acid, tartaric acid, fluminic acid, ammonium compounds.
Sodium	See alkaline metals.
Sodium nitrate	Ammonium nitrate and other ammonium salts.
Sodium oxide	Water, any free acid.
Sodium peroxide	Any oxidizable substances, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, and furfural.

Chemical	Should Not Come in Contact With . . .
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate, similar compounds of other light metals, alkali metals, and alkaline earth metals.
Zinc (powder)	Sulphur.

3. CHRIS* Compatibility Chart

Obtain the group for the chemical and then read the chart. Wherever an X intersects an incompatibility exists.

X represents unsafe combinations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1 Inorganic Acids																								
2 Organic Acids	x																							
3 Caustics	x	x																						
4 Amines & Alkanolamines	x	x																						
5 Halogenated Compounds	x		x	x																				
6 Alcohols, Glycols & Glycol Ethers	x																							
7 Aldehydes	x	x	x	x		x																		
8 Ketones	x		x	x	x		x																	
9 Saturated Hydrocarbons																								
10 Aromatic Hydrocarbons	x																							
11 Oleins	x					x																		
12 Petroleum Oils																								
13 Esters	x		x	x																				
14 Monomers & Polymerizable Esters	x	x	x	x	x	x																		
15 Phenols			x	x			x							x										
16 Alkylene Oxides	x	x	x	x		x	x							x	x									
17 Cyanohydrins	x	x	x	x	x		x									x								
18 Nitrites	x	x	x	x												x								
19 Ammonia	x	x				x	x						x	x	x	x	x							
20 Halogens			x			x	x	x	x	x	x	x	x	x	x	x								
21 Ethers	x													x										
22 Phosphorus, Elemental	x	x	x																					
23 Sulfur, Molten									x	x	x	x				x								
24 Acid Anhydrides	x		x	x		x	x						x			x	x	x	x					

*CHRIS - Chemical Hazards Response Information System (U. S. Coast Guard)

M. Handling Spills

Most chemicals in the laboratory are used safely. However, occasionally a container is upset or a bottle is dropped with a resultant spillage of chemicals. Chemical spills are hazardous to teacher and students. It is too late to start thinking of how to deal with a spill after the spill occurs.

1. General Considerations

a) The teacher should be prepared to handle chemical spills rapidly and effectively.
b) Definite instructions should be given to the pupils regarding spill cleanup with each experiment.
c) If appropriate, have the students clear the area.
d) The spill cleanup technique the teacher will follow will be dictated by the particular family of the chemical involved.
e) The teacher should have a knowledge of the hazard potential and characteristics of the particular chemical.

f) Read the manufacturer's label.
g) A mop, bucket, and mopping up cloths should always be available.
h) Sand, and appropriate buffer or absorbent, should be available for neutralizing spills. Cat litter products are not suitable for neutralizing spills.
i) Rolls of absorbent paper (e.g., toilet tissue) are useful for mopping up some spills but care should be taken with flammable or corrosive liquids and, above all, with powerful oxidizing agents.
j) If kept in small plastic bags the buffer or absorbent contents can be easily poured out, or the bag cut open and the contents thrown on the spill from a short distance.

2. Mercury

Mercury, a commonly used liquid in the laboratory, presents a special hazard.

a) Mercury poisoning produces many physiological effects including mouth sores and muscular tremors. It is primarily observed in persons who have been exposed to relatively high concentrations of mercury vapor over a period of years. This has occurred in mercury mines or in poorly ventilated laboratories where mercury was free to vaporize.
b) At 25°C, it has a vapor pressure of 1.7×10^{-3} Hg which is far above 400 times human tolerance levels if it reaches that pressure in a room. (Fortunately, room ventilation usually keeps the actual level in a room far below that pressure.) For this reason, mercury should always be stored in tightly-closed bottles.
c) Spilled mercury easily hides in corners and under immovable objects, thereby providing an undesirable source of mercury vapor.
d) Covering mercury with water or oil does not change the equilibrium vapor pressure of mercury in the air about it, but only reduces the rate at which mercury reaches that equilibrium value.
e) Mercury spillage is best removed by:
   - Sucking it up with a vacuum flask. This apparatus consists of a 6 mm glass tube drawn to a 1 mm tip opening, which is fitted to a trap connected to a water aspirator or vacuum pump.
   - Sprinkling the immediate area with powdered sulfur or sodium polysulfide solution.
   - Mercury reacts readily with sulfur to give HgS.
   - Since the formation of HgS occurs only on the surface of the droplets and a disturbance of the droplet produces a fresh Hg surface, treatment with sulfur is at best a temporary method for reducing the vaporization of mercury.
   - Allow 24 hours for the sulfur and mercury to react.
   - Carefully sweep up the mercury sulfide with a commercially prepared mercury brush. Do not use a broom.
   - Take care that shoes are not contaminated.
   - Domestic vacuum cleaners must not be used as they would redisperse mercury aerosols and increase the contamination.
   - Store all reclaimed mercury in tightly stoppered bottles.
   - Spilled mercury can be cleaned and recycled by industry or the university.
   - Commercial mercury spill cleanup kits are available (e.g., HgX).
   - If mercury spill is anywhere near a source of heat the liquid mercury should be contained as soon as possible because of the accelerated formation of poisonous mercury vapors.
   - Where possible, experiments or demonstrations involving mercury should be confined to plastic trays where mercury spills could be contained.

3. Acid Spills

a) Acid spills may be neutralized with powdered sodium bicarbonate ($NaHCO_3$), sodium carbonate (Na_2CO_3), or slaked lime ($Ca(OH)_2$). Note: Do not absorb nitric acid (HNO_3) with paper or wood products because explosive nitrocellulose may be formed.
b) Neutralized or diluted liquids may be absorbed with paper or solid absorbents.
c) Commercial absorbents are also recommended.
d) Dry sand may be used but is less effective.
e) Vermiculite should not be used on floor spills. Vermiculite creates a slipping hazard when wet.
f) The treated spill and its absorbent should be collected with a dust pan and brush.
g) Protective equipment (rubber gloves, goggles, etc.) should be worn.
h) Clean the contaminated area with soap and water and mop it dry.

4. Base Spills

a) May be neutralized with acetic acid, boric acid, other weak acids, or with sodium bisulfate ($NaHSO_4$).
b) Absorption and mopping up procedures are the same as for acid spills.
c) Protective clothing and equipment should be used.
d) Eye damage can rapidly occur from even dilute solutions of bases.

5. Flammable Solvent Spills

a) All flames and other sources of ignition should be immediately extinguished (e.g., brush-type motors).
b) All equipment should be shut down.
c) The room should be evacuated until it is decontaminated.
d) It is not recommended that the solvent be absorbed with paper towels or cloths. Paper towels, cloths, and other similar materials increase the surface area of the spill, resulting in a greater formation of flammable vapors.
e) Commercial absorbents specifically designed for solvent spills should be used when dealing with small quantities of flammable liquids in enclosed areas.

6. Alkali Metal Spills

a) Dry soda ash (Na_2CO_3) should be used to cover the area.
b) The alkali metal and soda ash should be mixed together and the resultant mixture added to butyl alcohol. Methyl or ethyl alcohol may be ignited by the alkaline metal.
c) Let stand for 24 hours.
d) Dilute and add to the drain with a large excess of water.

N. Disposal of Wastes

1. General Considerations

Waste, by definition, is anything not used or in use, unused, unproductive or not properly utilized, or anything left over or superfluous, as excess material, by-products, etc., not of use for work in hand. Waste chemicals and materials generated in schools usually conform to this definition: chemicals previously stocked but no longer used in the curriculum; compounds designated as hazardous substances no longer used; chemicals that have expired their shelf life; and, waste chemicals generated from experiments or contamination.

The disposal of many waste products presents a major problem and requires trained personnel with proper equipment and a knowledge of safety pro-

cedures, available disposal techniques, and the properties of chemical compounds with regard to safety concerns and environmental effects. Each compound must then be assessed as to what is the best disposal technique, taking into consideration available resources such as type of landfill or disposal ground available and sewer systems on-site.

Because of the complexity involved in the disposal of many compounds, it is recommended that such personnel be contacted before any disposal is attempted. Information and assistance in this area may be obtained from the Manitoba Department of Consumer and Corporate Affairs and Environmental Management Division; telephone 895-5266.

Some compounds of known chemical reactivity and toxicity generated as waste in small quantities from school laboratory experiments may, however, be disposed of on-site provided the following criteria are followed:

a) The teacher should have full knowledge of the reactivity and toxicity of the compound.
b) Under no circumstances should flammable, reactive, or toxic chemicals be disposed of without contacting resource personnel.
c) Solid materials that meet the previous criteria, such as common salts and powders, may be landfilled or buried at disposal grounds, provided there is no access to the chemicals by the general public.
   - In an area that is serviced by a solid waste disposal service, these compounds may be packaged and placed into the refuse system only during the collection of the refuse.
   - In areas not serviced, the compounds may be packaged and taken to the disposal ground then immediately buried.
d) Liquids that meet the previous criteria may be carefully diluted with copious amounts of water into the sewer system.
   - In areas that utilize a septic field system, these compounds should be taken to a disposal ground and emptied, exercising care and caution.
   - The containers should be buried immediately after disposal.
e) Unless the above criteria are met or there is any doubt as to the disposition of the compounds, resource personnel should be contacted.

2. Further Teacher Considerations

a) Definite instructions for waste disposal should be given to the students with each experiment.
b) All waste disposal containers should be labelled to indicate contents.
c) If at all possible, dispose of all wastes at the conclusion of each experiment. Do not mix the wastes from several experiments.
d) Provide separate, labelled containers for uncontaminated paper, solid chemical waste (stone jar with lid), and broken glassware (metal container).
e) Special containers may also be required for other types of waste such as for flammable solvents (safety can).
f) Do not dilute unwanted chemicals with water and dump down the drain. Contamination of the environment, corrosion of the plumbing, explosions due to the accumulation of flammable vapors or the formation of explosive oxides may occur.
g) Do not indiscriminately bury or incinerate chemicals.
h) Explosive materials and their containers should not be placed with regular waste. There is danger of explosion where waste is being incinerated.
i) Great care must be taken to make sure that radioactive materials do not enter the normal waste disposal operation but are properly segregated and handled in accordance with recommendations of the Atomic Energy Control Board.

XI. PHYSICS

A. Introduction

As with any science laboratory, care must be exercised while working in a physics laboratory. The following rather detailed information concerning potential hazards and recommended operating procedures in a physics laboratory has been compiled to guide teachers and act as a ready reference. Teachers are referred to the information on general safety, accident prevention, and first aid found elsewhere in this publication.

B. Physical Facilities

Ideally, physics laboratories should include the following features:

1. A master shut-off switch capable of cutting power to all stations and valves which are easily accessible to the teacher and clearly marked.
2. "Ground fault interrupter" or similarly protected circuitry installed in all laboratory electrical systems whenever and wherever possible.
3. Grounding procedures to pipes, etc., including both solder and mechanical (screw, etc.) joints, done by a properly certified person.
4. Where circuit breakers are not provided, electric lines to pupils' tables should be protected by fuses protected in closed panel boxes only.
5. Switches, fuses, circuit breakers, and other control devices should be identified so that their open and closed positions are quickly recognized and the circuits they control can be easily determined.
6. Fusing should be such that overheating or burn-out of equipment or wiring is not possible.
7. In high power situations (e.g., 115/230 V AC/DC with high current use) all switches or other contacts should be enclosed to prevent accidental touching, electrical spark danger to eyes, or possible fire hazard.
8. No exposed live electrical switches should be allowed on panels available to students.
9. Non-sparking switches throughout science laboratories should be provided.
10. Special receptacles for heavy loads should be provided or installed professionally (e.g., as for stoves, dryers, motors with high power start requirements).
11. Electrical outlets should be on pedestals or splash boards to prevent entrance of water by flooding.
12. No power-carrying lines should be permitted to cross sinks or other similarly grounded systems.
13. Enough electrical outlets (three-prong type) should be available to avoid the use of extension cords and their hazards.
14. Flooring should neither be slippery nor transmit an electrical shock when wet.
15. Wide aisles and exit passages should be provided.
16. Furniture should be sturdy, with rounded corners and edges.
17. Racks or drawers should have partitions for sharp tools.
18. Shelves should have rimguards and should be readily accessible so that apparatus and containers can be easily and quickly reached and replaced.

C. Housekeeping

Although adequate housekeeping in a physics laboratory may be less complicated and require less time than in chemistry, it is nevertheless an integral part of the safety program in schools. The following procedures are recommended.

1. Develop an effective control or inventory system. All new equipment should be checked before use to establish manufacturing errors (e.g., incorrectly grounded plugs).

2. Have proper procedures for the repair and/or replacement of all broken or damaged equipment and undertake repair immediately.
3. Carefully return all apparatus and materials to their designated storage area immediately after a demonstration. Take care to avoid bumping or sudden jarring of apparatus.
4. Wrap apparatus that needs to be kept sharp or well protected against rust and fumes in some suitable material. (Corks are useful in protecting protruding points.)
5. Place CAUTION and DANGER signs so that they are readily visible for such hazards as: radiation, microwave, lasers, or other physically dangerous equipment or materials.
6. Provide for color blindness with respect to color coding and for warning signs or labelling directions.
7. Wear suitable protective clothing to guard against fire hazards and accidents.
8. Keep contaminated clothing in the lab area.
9. Exercise care in the choice and use of fire extinguishers. Class C (CO_2) or multi-purpose dry chemical type fire extinguishers are to be used on electrical fires.
10. Use glass or other protective devices for handling hazardous and irritating fibres found in insulation, glass wool ("angel's hair"), etc.
11. Do not use asbestos in the laboratory.
12. If any mercury is spilled, take immediate precautions to reduce possibilities of excessive exposure to the vapor. (See pages 47 to 48 for information on handling mercury spills.)

D. Equipment

Physics laboratories should have the following equipment available:
1. An explosion shield for the demonstration table (may be shared with chemistry and biology).
2. Carefully planned storage spaces and security, where required, for all equipment, especially:
   a) vacuum tubes (Crookes);
   b) oscilloscopes and Van der Graaf machines;
   c) radioactive sources and geiger counters;
   d) transformers, induction coils, and motors.
3. Appropriate monitoring equipment where needed (geiger counters, smoke detectors, radiation dosimeters, etc.) to give danger signals or warnings for hazardous situations or radiations.
4. Appropriate fire extinguishers and fire blankets.
5. One first-aid kit for every room.
6. Tools with non-conducting handles for working on electrical devices, even when the power is shut off (e.g., pliers, screwdrivers, etc.).
7. Easily accessible equipment to clean up broken glass.

E. Electrical Equipment and Procedures

Appliances should bear CSA or equivalent seal of approval or be certified safe by authority in jurisdiction or their inspectors.

1. Placement

   a) Place and use electrical equipment in safe areas such as dry surfaces, non-metallic floors, and away from flammable or volatile materials.
   b) Do not store highly flammable liquids near electrical equipment because of the potential for accumulation of vapors and spark ignition. Static electricity can cause explosions in dusty conditions and when pouring non-conducting flammable liquids.
   c) Do not use spark sources such as switches near volatile substances.

2. Grounding

a) Use three-wire grounding cords on all equipment and appliances using 117-120 volts.
b) Grounded metallic objects should not be allowed to come in contact with live wires.
c) Do not use multiple plugs in electrical outlets.
d) Have electrical power tools grounded unless approved as "double insulated."

3. Current-Carrying Wires

a) Avoid the use of extension cords and their hazards by having enough electrical outlets.
b) If you must use extension cords, take note of the following:
   - All extension cords should be CSA approved and properly grounded.
   - Avoid using household type extension cords in laboratories.
   - Electrical cords should not be frayed, twisted or kinked, and should be protected from sharp objects.
   - If moisture, heat, or chemicals are present, the electrical cord should be the proper type to resist such conditions.
   - Extension cords should not be strung across windows or in such a way that they become a tripping hazard. Cover any cords which must stretch across an aisle, space, etc., with mechanically protective covers or shields.
c) Inspect often for damaged cords and plugs, and frayed, weakened attachment points.
d) Connections should not be made to light sockets for the purpose of operating electrical appliances, light extensions, or portable equipment.
e) A current carrying wire used near any metal object must be permanently protected with an insulating cover to avoid possible contact.
f) Do not allow students to: construct circuits and/or make connections without teacher supervision, use improper size extension cords, by-pass fuses, use exposed connections, use high voltage sources for low voltage situations, etc. Check all student-constructed circuits prior to allowing the flow of electricity to begin.

4. General Equipment - Use and Maintenance

a) All electrical equipment should be kept in top condition.
b) There should be procedures to guard against implosion dangers when replacing or working with all bulbs such as reflector flood, aquarium, and ripple tank, show-case, etc.
c) Components of electrical equipment should be enclosed to prevent accidental contact with current-conducting parts, and tampering by students.
d) Do not overload electrical circuits.
e) Unless motor-driven apparatus is essentially portable, it should not be connected to wall outlets. Caution should be exercised when a motor requiring a starting current of more than 1100 watts is plugged into a wall outlet.
f) Do not exceed the manufacturer's instructions when using electrical equipment.
g) Periodically check wiring, outlets, and switches for defects, replacing all broken or cracked cover plates on outlet or switch boxes.
h) Repairing or altering of electrical equipment or wiring should be done by qualified personnel only. Power should be shut off or disconnected before any repairs are attempted or installations made. Power disconnect tags should be used whenever electric equipment is taken out of service for repair and power must be returned to supply lines.

5. High Voltage Equipment

Electronic supplies and equipment, such as electrolytic condensers, can be responsible for personal injury, fire, and explosions, and even death.

a) Various high voltage generators and some motors produce ozone which is both hazardous and toxic.
b) Areas with high voltage equipment such as transformers, induction coils, U.V. lamps, lasers, radiation, and microwaves should be clearly marked and be restricted to authorized personnel only. CAUTION: Oil-filled transformers and condensers may contain PCB (polychlorinated biphenyl). Proper disposal procedures should be followed for this hazardous chemical.
c) In handling the so-called "transformerless" type of radio, where tubes are connected in series and the set works directly from the line (115 v AC), caution must be observed to prevent any grounded metallic object coming into contact with the metallic chassis.
d) Caution must be exercised in demonstrating, adjusting, and/or using image tubes from T.V. sets or cathode-ray oscilloscopes which have been removed from their protective housing. They may produce a high voltage discharge from the rear of the tube.
e) In using standard transformer radios, T.V.'s, oscilloscopes, etc., pupils must be cautioned on the handling of "B" (high) voltages. The high voltage 'secondary' is in the order of 600 V AC and the rectified "B" voltage is about 300 V DC. Severe shock and burns can result.
f) Equipment incorporating cathode-ray type tubes may not always be protected by "bleed off" devices and may retain a very high and dangerous charge for many hours (e.g., T.V. sets).
g) When discharging capacitors:
   - Make sure the current is off - disconnect from the power source.
   - Short the terminals to prevent severe shocks.
h) Even after grounding out, certain capacitors can partially recharge themselves in what is known as a "residual effect," necessitating further careful shorting techniques.
   - High resistance "leakage" or "bleeds" should be provided whenever possible.
   - Most power supplies are equipped to bleed off stored charge, but this may take some time.
   - Students should be instructed in the proper procedures for discharging this type of apparatus. (0.25 joule gives a heavy shock; 10 joules are fatal!)
   - Before work is started on internal parts, be sure the apparatus is properly cooled.
i) Polarized electrolytic type capacitors can explode if connected with wrong polarity. Rated charging capacities should never be exceeded.
j) Induction coils must be plainly labelled to show the low and high voltage connections in order to avoid the possibility of shocks.
   - There is the danger of shock from the secondary coil as well as the danger due to self-induction when coils (and internal capacitor) are disconnected.
   - Proper polarity should be observed on the D.C. connections.
k) Periodic checks should be made for high voltage static accumulation.

6. Batteries

Care should be observed in the handling of any storage battery. It is a source of danger in spite of its low voltage because of the acid present and the high current which may be drawn from it on a short circuit.

a) Batteries should be charged in a well-ventilated area.
b) If it is necessary to charge the battery in a confined area, then safety caps should be used.

c) Jump-starting automobiles and the associated hazards should be made the subject for classroom instruction.

d) Batteries that are safe electrically, may, under certain conditions of charge or heating, become potential explosive devices.
   - A fine acid spray develops, and is particularly hazardous, under or immediately following conditions of charging storage cells or batteries. Students should be kept away from the spray as it is harmful if inhaled or allowed to get into the skin.

e) A fully charged battery on 'trickle charge' produces both hydrogen and oxygen with hydrogen concentration as great as 20% (well over the explosion limit of 4%). This produces a very explosive mixture. This type of hazard is not well known!
   - All ignition sources, including cigarettes, must be kept away from lead/acid batteries. Hydrogen can be ignited by hot tobacco ash.
   - A resulting explosion can shatter a battery case and throw sulphuric acid a distance of more than a metre.
   - The charger should always be disconnected from its power source (outlet) before disconnecting at the battery terminals.
   - The caps should be loosened in order to eliminate the accumulation of hydrogen gas (or hydrogen-oxygen for conditions of over-charge).

f) Discard, in a safe manner, leaking batteries, burnt-out bulbs, and other potentially hazardous equipment.

F. Degree of Hazards with the Use of Electricity

1. Theoretical Considerations

It is important that basic precautions be taken in the use of electrical equipment in science laboratories because the possibility of electric shock and fire exists even with low voltage.

a) In terms of electrical hazard, the voltage, amperage, and resistance must be considered in combination. Electrocution can be caused by very low voltage if a low resistance allows a large amount of current to flow.

b) Any voltage may cause electrocution. The effect on the body is determined by the amount of current flowing through the body, and not the voltage.

c) A fatal shock can be received, under certain conditions, from using equipment with normal electrical wiring.

d) The circumstances at the time of contact with the electrical equipment will determine the amount of shock current.
   - A person with wet hands and/or standing on a wet surface would make an excellent path for the electricity to the ground. E.g., a dry skin resistance of 500,000 ohms can become as low as 1,000 ohms with wet or sweaty hands.
   - A high amperage allowed through the body makes a 110 volt line very dangerous.
   - A large area of contact tends to make the resistance of the body low (e.g., entire hand in contrast to one finger).
   - Two hands make it possible for the current to pass through the heart region, producing fibrillation potential.

e) Symptoms and progress of electrical shock are:
   - "Tingle" from electrical leakage. (Immediate attention is required.) The body's electrical resistance is quite small, and once the initial resistance is overcome large current flows may take place.

f) Even small amounts of current may make it impossible to let go of source.

g) In pupil investigations involving use of hands-on D.C. electric circuits, e.g., "Batteries and Bulbs" types of activities, voltages should be limited to a maximum of 30 volts.

h) Serious electrical shock, burns, and explosions have been recorded in the Department of Labour's accident investigation files with the use and improper handling of storage batteries (e.g., car batteries).
i) Electrocution has been caused by using appliances operating on 110 volts (AC) or 42 volts (DC).
j) Death has been recorded for voltages as low as 60 V.
k) When using 110 volt lines or higher voltages, the teacher should consider two fundamental points.
   - The body must not become a path for electricity.
   - Conditions must be such that if the body does become the path for the electricity, the amperage will not be dangerously high.

Electric Shock Chart

Condition	Current (60 H_2)
Perception of Current (Minimum)	
Tongue	50 microamperes (μa)
Grip contacts	0.5 μa
Tapping contact	0.2 μa
Let-Go Threshold	
Adult male	9 μa
Adult female	6 μa
Child	5 μa
Painful to Severe Shock	> 10 μa
Lethal Currents	
Prolonged contact (respiratory arrest)	18 μa
Short contact (1 to 2 seconds)	
Ventricular fibrillation	
Adults	60-120 μa
Children	30 μa
Absolutely fatal	> 200 μa

Note: If immediate attention is given, currents between 100 and 200 μa do not usually cause death although the victim will receive severe burns and become unconscious.

2. Instructions in Case of Electrical Shock

a) Turn off the current.
b) Send for a physician at once.
c) Use an insulator to remove contact from the victim.
d) Apply artificial respiration, if needed.
e) Do not stop giving artificial respiration even if the victim shows signs of early rigidity or stiffening.
f) If no pulse is found in the victim, immediate CPR by a trained practitioner is required.
g) Efforts for revival should be continued until medical assistance is available.
h) Keep the victim warm, using blankets.
i) Place the victim in the recovery position.

G. Student Regulations for the Use of Electrical Equipment

The following rules are suggested. It is strongly recommended that each teacher establish, post, and frequently review rules and procedures.

1. Do not manipulate any apparatus set up for demonstration unless under the teacher's supervision.
2. Do not "experiment" with electrical circuits and voltages. High voltage and makeshift assemblies may continue to cause trouble.
3. Ensure that the work areas, including floors and counters, are dry whenever electric current is involved. Non-conducting floors, rubber mats, or approved carpeting makes the use of electrical equipment safer.
4. Never touch a ground, such as a water pipe or sink, and an electrical circuit simultaneously.
5. Avoid bringing both hands into power contacts.
6. Handle all electrical circuits with dry hands.
7. Never assume that physical experiments are free of hazards just because they are printed.
8. Electrical appliances should be treated with respect at all times. Voltages, such as 115/230 volts AC, can be extremely dangerous.
9. Never connect electrical apparatus requiring more than 1100 watts to wall outlets on any one circuit.
10. Do not continue to use an electrical apparatus after liquid has been spilled on it. Turn the apparatus off immediately and allow it to dry thoroughly inside and out prior to using it again.
11. In inserting an electrical plug, hold the plug so that any flashbacks (due to a piece of short-circuited equipment) will not burn the palm of the hand.
12. Take care not to touch the metal parts of the plug when inserting it into an outlet.
13. Never remove the third prong of a three prong plug to accommodate an outlet or extension cord.
14. See that no metal object is exposed where "live" wires may make a contact (stands, sinks, jewelry, and the like).
15. Never "short circuit" dry cells or storage batteries.
    - High temperatures developed in the connecting wires can cause bad burns or even set fires.
    - Wet cell batteries can produce very high current flows through personal jewelry or conducting tools.
16. Long hair, loose clothing, ties, etc., should be protected from all moving shafts, pulleys, and the like, involving powered equipment.
    - Long hair should be protected by hair nets, etc.
    - Long hair is also a fire hazard when working near flame sources.
17. In any electrical setup, the main source of current (110 V AC plug-in) shall be the <u>last</u> connection to be made and the <u>first</u> disconnection to be made.
    - Disconnect by pulling the plug, not the cord.
18. Do not touch any part of the circuit while the power is on.
19. Do not change connections while power is on.
20. Where possible, electric current should be sent through a limiting resistance (e.g., a light bulb) so that no more than the desired current will travel through the apparatus (e.g., testing conductivity of solutions).
21. Do not touch another person's equipment unless instructed to do so.
22. Be certain that the apparatus is disconnected from the power source and allowed to properly cool prior to touching inside parts.
    - Use caution before grasping or lifting apparatus.
23. Ensure that cables and leads are properly protected from both chemical and mechanical damage.
24. Return all apparatus and materials to their designated storage area immediately after use.
25. Inform the teacher of any defective equipment (e.g., burnt-out bulbs, frayed cords, leaking batteries).

H. Ionizing Radiation

1. Introduction

Although radiation has always been a part of our environment, radiation from technological sources may greatly exceed natural radiation. The properties of radioactive materials are such that they have numerous applications in scientific research, medicine, and industry. It is anticipated that these applications will not only continue, but increase dramatically in number and kind. To reduce the chance of injury, students should understand basic concepts related to radiation, and should know what dangers exist and how they can be avoided.

Teachers may wish to provide their students with an opportunity to investigate radiological theory, handle limited quantities of the materials, and to learn the necessary skills and techniques employed in the safe handling of such materials.

The use of radioactive materials is carefully regulated by federal and provincial laws. Teachers or other prospective users are advised to obtain information provided for users of such materials.

Teachers can obtain radioactive materials of low level radiation (low microcuric range) for experimentation. No elaborate safety equipment or protective measures are required for using such materials. Minimum quantities only should be ordered since the combination of many low activity samples may present a hazard potential.

2. Degree of Hazards

The human senses cannot detect radiation. However, special instruments can detect radiation hazards to alert us to the need for protection.

a) Maximum dose limits are set by the International Commission on Radiological Protection.
- The unit of absorbed dosage, the "Rad," is defined as 100 ergs of energy absorbed per gram of material or 0.01 joule per kilogram.
- For all practical purposes, the number of Rads is numerically equal to the number of "roentgens" (a unit of exposure relating to the quantity of "X" or "gamma" radiation arriving at a specified place).
- At present, it is well recognized that over-exposure to atomic and x-radiation is harmful.
- Although there is considerable information on the possible kinds of injury and the dose levels necessary for their development, certain features are still not clarified.

NORMAL UPPER LIMITS FOR DOSE ACCUMULATION BY PERSONS, OTHER[1] THAN PATIENTS UNDERGOING AN APPLICATION OF THERAPEUTIC OR DIAGNOSTIC X-RAYS, WHO ARE NOT X-RAY WORKERS

Organ or Tissue Subject to X-Ray Exposure	Normal Upper Limits for Dose Accumulation in Organ or Tissue in One Year
Whole body, gonads and bone-marrow	0.5 rads
Skin, bone, thyroid	3.0 rads
Hands and forearms, feet and ankles	7.5 rads
Other single organs	1.5 rads

[1] Manitoba Regulation 207/79 printed in the Manitoba Gazette, Vol. 108, No. 45, November 10, 1979, p. 705.

In order to keep the population dose reasonably low, the International Commission on Radiological Protection both recommended annual dose limits for pupils under the age of 18 relative to the limits acceptable for the general population, and that during an experiment, a student receive no more than one-tenth of the annual dose limits. The maximum permissible exposure for students should not exceed 50 mR per year.

Radiation to the general public may come from a number of sources such as background, radiation, medical diagnosis and therapy, and other man-made sources.

The radiation dose decreases as the square of the distance from a source.

b) Basically, two types of exposure to radiation are possible:
   - external to the body.
   - internally deposited by ingestion or entry through other openings in the body.

c) Radiation effects on human beings are of two general kinds:
   - injury to body tissues (somatic effect).
   - injury to germ plasm (genetic effect).

d) The doses necessary to produce early or late somatic injury are, in general, considerable.

e) For most radiation in a school, overdoses could be received by an individual only as a result of negligence or ignorance of the presence of radiation.

The Effect of Radiation Overdose on the Body

Illness	Cause	Effect
Radiation injuries	Overdose of less penetrating radiation.	Injuries to a small part of the body, e.g., burns, loss of hair, and skin lesions. Hands are most often affected because contact is usually made with hands.
Radiation sickness	Massive overdose of penetrating external radiation.	Nausea, vomiting, diarrhea, malaise, infection, hemorrhage, perhaps death.
Radioactive poisoning	Dangerous amounts of certain types of radioactive materials enter the body.	Anemia, cancer, etc.

f) Genetic damage can also be caused by radiation.
   - Genetic damage is more subtle, likely to be cumulative, and only may become manifest in future generations.
   - According to present knowledge, there appears to be no lower limit to the amount of radiation which may produce some genetic effect, the extent of which may be expected to increase with the dose of radiation.

3. Production of X-Rays

a) Voltage control used in the operation of gas discharge and glow-tube type apparatus should be understood. The following information is provided to help teachers understand some of the more important points:
- When a charged particle is suddenly stopped, it loses energy both by conversion into heat and by radiation in the form of electromagnetic radiation, including X-rays.
- If this energy is produced by less than 10,000 volts it is unlikely any escaping radiation will penetrate even thin layers of glass and, therefore, except in most unusual circumstances, no hazardous X-rays will be emitted by devices operating at less than 10,000 volts.
- The source of high voltage used to cause gas discharge in "glow tubes" is commonly an induction coil. This latter device is usually equipped with an adjustable spark gap that can be used for measuring and limiting voltage.

b) The following table shows the approximate relationship between a spark gap and the voltage necessary to jump that gap. While the values are not exact, since they vary with temperature, pressure, humidity, and needle diameter, they do serve as a guide.

TABLE OF SPARK GAP VERSUS VOLTAGE

Peak Voltage (approx.):	10 000	15 000	20 000	30 000	40 000	50 000	60 000
Spark Gap in cm: (needlepoint separation for the secondary output terminals)	1.0	1.3	1.8	2.7	3.8	5.2	6.8

c) The following listing will provide some guidance in regard to the use of equipment which may produce ionizing radiation in investigations or demonstrations.
- Unsafe for Use:
  - X-Ray tubes
  - Fluoroscope
- Safe, if correctly connected, and operated with proper precautions:
  - Magnetic Deflection tube
  - Heating Effect tube
  - Fluorescent or Shadow-effect tube (e.g., Maltese Cross)
- Little or no X-radiation (safe):
  - Kinetic energy tube
  - Canal ray tube
  - Geissler tubes
- In addition, radiation hazards occur with the following non-ionizing sources:
  - Ultraviolet lights
  - Lasers
  - Microwave generators, ovens, etc.

4. Discharge Tubes

In addition to recognized radiation sources, many electronic devices emit radiation as an unwanted byproduct, either in their normal operation or under special circumstances.

a) Ozone, both hazardous and toxic, may be produced as an unwanted by-product related to operations involving high voltages and discharge tubes.
b) High voltages in conjunction with vacuum or gas discharge tubes produce biologically damaging radiation and hence should be controlled.
   - At high voltages X-rays can be produced.
   - Examples of electron beam tubes that can generate X-rays are: Crookes tubes, color T.V. sets, cold-cathode gas discharge tubes, high power Klystron tubes used in radios, and Fluorescence Effect tubes.
c) All X-ray generating equipment should be checked periodically for stray radiation.
d) Shielding from possible ultraviolet, infra-red, or X-rays should always be made available when certain generators, electron microscopes, cold-cathode discharge tubes are used for demonstrations.
e) Exposure rate from gas discharge tubes varies considerably depending upon:
   - the vacuum present in the tubes;
   - the voltage applied;
   - anode or target material;
   - the shielding provided by the tube itself.
f) The use of a built-in spark gap to limit the voltage should be part of instrument construction.
g) Gas discharge tubes should only be used when the polarity of the source is known (an induction coil should not be used as a power source unless its output polarity is known).
h) For the operation of the cold-cathode ray or gas discharge tubes, and similar, it is recommended that AC to DC, diode-controlled transformers be used as a power source, thus controlling the polarity of the output voltage.
   - In such instruments color coding of tubes to match color coding of the clamps, plus labelling as to positive and negative, may help control reversal of tubes when design fittings are similar at both ends, since knowledge of the voltage and polarity required for operating the device is recommended.
   - Cathode-ray type computer terminals have not been found hazardous at typical operating voltages up to 16,000 volts.
i) Since the naming and condition of tubes will vary, tubes which are suspected as being hazardous can be checked by referral for inspection by the Inspector, Radiation Protection Section, Physics Department, Manitoba Cancer Foundation, 700 Bannatyne Avenue, Winnipeg, Manitoba, R3E 0V9, (Phone: 787-2211).

5. Guidelines Pertaining to the Use of Radioactive Material

Carefully planned and executed safety precautions are essential in the use and storage of radioactive materials, even when the materials are of small radiation hazard potential.

a) Radioactive solutions should not be used without complete knowledge and specific information concerning the handling of these materials.
b) Radioactive isotopes, beyond a scheduled quantity, require a licence. Compliance with licencing conditions should ensure safety in their handling.
   - On the day when radioactive isotopes will be used, a large sign or poster with the radiation symbol should be prominently displayed. Visitors should not be allowed in the laboratory except by special arrangement.
c) All animals or plants used with such radiation sources also become potential radiation sources and must be treated according to licencing rules.
d) Where possible, the teacher should set aside a working area exclusively for handling radioactive materials.

- Working areas should have the kinds of floors, walls, work surfaces, and furniture that may be easily washed when decontamination procedures are being used.
- Remove all unnecessary equipment from the working area.
- Any transportation of material should be done in shielded and enclosed containers constructed to prevent accidental release of the source in case of accident.

e) Radioactive sources are commercially available in two forms: sealed and unsealed.

Sealed Sources

- The material is permanently embedded within some other medium such as metal or plastic.
- Sealed sources are generally safer to use and easier to handle.
- Useful information is usually affixed to the sealed source (e.g., date of manufacture, identity of isotope, and radiation strength).

Unsealed Sources

- The material is supplied as a dry powder or in an aqueous solution.
- In order to prevent absorption from solution, the material may contain a "carrier."
- An additive may be present to suppress the production of undesirable chemical forms of the radioactive element.
- It is essential that permanent, complete records associated with these materials be maintained (e.g., kinds and amounts, date of receipt, level of radiation).

f) Radioactive materials that are received should be clearly labelled with the printed name of the radioactive substance, marked with the radiation caution symbol and labelled with the words, "Caution Radioactive Materials."
- Laboratory supply houses have rolls of tape bearing this symbol available for purchase.
- Information indicating the level of radioactivity for a particular date should also be included on the label.

g) The ionizing element in certain smoke detectors, when removed from the detector, produces hazardous radiation, which, if unknown, may be dangerous to handlers.

h) Luminous dials of the old-style radium-based type are considerably more dangerous than the newer tritium type. Such dials may be found on equipment produced several years ago and which is still in use or is being handled or dismantled, e.g., where components are being reused by students or teachers.

i) If a student should bring a radioactive specimen to the laboratory, check its level of activity to be certain that it is not dangerously high.

j) Radiation dosage should be reduced by such methods as shielding, distance, limiting of working times, handling with forceps, and the like.
- Radiation dosage is related to the square of the distance from the source.

k) New procedures should be practiced with non-radioactive materials.

l) In general, active or contaminated materials should be retained within the laboratory at specific locations.

m) When dispensing radioisotopes to students, the teacher must know the quantity students may be expected to handle with relative safety.
- Sources should remain locked up.
- Sources should be locked up between each investigation period.
- Quantities of materials should be checked at the end of each class.
- Sources should be counted before and after each class.

n) The containers of all experimental plants should be clearly labelled.

o) Apparatus that has been in contact with radioactive materials should be stored separately and retained for that exclusive use.

p) All places, personnel, and equipment that have been in contact with radioactive materials should be systematically monitored.

q) Keep accurate, up-to-date records of the students' participation in experimentation involving ionizing radiation.

- Indicate students' attendance/absence.
- Indicate the amount of exposure on a given date.

6. Storage of Radioactive Materials

a) Most radioactive materials, up to and including millicurie quantities, can be stored safely in the original containers.
b) Store radioactive materials in a cabinet that provides adequate shielding.
c) All containers, boxes, lead shields, and cabinets containing radioactive materials should be clearly marked "Radioactive Material" with a yellow and magenta warning label.
d) Small quantities of radioactive materials may be stored in small wooden, plastic, or sheet metal cabinets.
   - Laboratory supply houses have cabinets about the size of a school laboratory drying oven available for purchase.
e) Storage cabinets should be locked to prevent unauthorized entry or theft.
f) Supply houses and pharmacists can provide thin, plastic boxes which will provide sufficient shielding to store smaller alpha and weak beta sealed sources.
g) Sources used for radiation field investigations should be sealed and contained so as to resist mechanical disruption.
   - Sealed sources should be regularly checked for contamination or leakage.

7. Handling Low Activity Sources

a) Wear the dosimeter or film badge, if required.
b) Number and sign out sources so that each can be traced.
c) In a room where radioactive materials are being used, do not permit the consumption of food or beverages, smoking, chewing gum, or the use of cosmetics.
d) Spread waterproof paper over working area to simplify "clean-up."
   - Often, the most practical procedure is to confine such work to a series of large plastic trays lined with paper towels, diaper paper, or disposable diapers.
   - This procedure may protect the working surface from contamination.
e) Ensure that students understand that all wounds, spills, and other emergencies are to be reported to the instructor immediately.
f) Radioactive sources must not be allowed to come in contact with the skin or near the mouth, eyes, or open sores.
g) Suitable protective clothing (lab coats and disposable gloves) should always be worn, should not be removed from the area, and should be monitored at the end of each working session.
h) Mouth operations (pipetting, licking labels, etc.) are forbidden.
i) Use tongs or tweezers for solid specimens.
j) Use a fume hood if inhalation of radioactive vapor or powders is a possibility.
k) Hands must be scrupulously washed and monitored with a geiger counter after each class.
   - Disposable towels should be used.
   - Contamination remaining after thorough washing should be reported to the teacher.
l) Area of use should be monitored with proper radiation detection equipment following the use of any radioactive materials.
   - If required, the area of use should receive decontaminating procedures and a further survey.
m) All written records, if required, should be completed before leaving the laboratory.

8. Decontamination

Contamination can be prevented by meticulous attention to safe procedures in the handling and storage of radioactive materials. In the event of a spill, however, the following guidelines should be followed. These procedures will vary with the amount of the spillage and the kind of contamination on a particular surface.

a) Immediate Steps to Take

Spillage	Procedure
Skin-Spot Contamination	Wash with soap and water. Use a soft brush. Avoid damaging the skin. Repeat if necessary.
Glassware	Wash with detergent and hot water. If necessary, use a cleaning solution.
Clothing	Wash with hot water and detergent.
Painted Surfaces	Wash with hot water and detergent. If contamination remains, wash with ten percent hydrochloric acid.
Laboratory Taps and Drains	Use large volumes of water. Scour with rust remover or cleanser.
Rubber	Wash with hot, soapy water. Rinse with dilute nitric acid. Follow with cleanser. Rinse.
Ceramic Tile	Wash with hot water and detergent. Follow with mineral acid, trisodium phosphate, or ammonium citrate.
Linoleum	Wash with hot water and detergent. If required, wash with kerosene or ammonium citrate solution.
Metal	Wash with hot water and detergent. Wash in dilute nitric acid or ten percent sodium citrate solution, if necessary.
Wood	Wash with hot water and detergent. If contamination is from a long-lived isotope, the surface should be planed.
Concrete	Wash with hot water and detergent. If necessary, wash with 32 percent hydrochloric acid.

b) Monitor the contaminated surface for residual radioactivity after the first step of the decontamination procedure.
c) Continue or repeat the process if decontamination has not been successful.
d) Clearly mark the spill area and the radioisotope involved (e.g., I^{131}).
e) Use a labelled "contaminated" can to contain all disposable materials used to clean the spillage.
f) Ensure that the disposal of radioactive wastes follows proper procedures designated for the locality and the kind of material to be disposed.

I. Non-Ionizing Radiation

1. Ultraviolet

The wavelength of ultraviolet radiation (UV) is generally between 390 millimicrons and 1800 millimicrons. Germicidal lamps are a common source of this type of radiation.

a) Hazards of the User

- Ultraviolet light or radiation produces an acute reaction on the eye by being absorbed by the outer layers, the cornea, and the conjunctiva.
- The shortest UV wavelengths (<3100 Å) are the most harmful to the eyes.
- An electric arc provides a large amount of ultraviolet radiation.
- The symptoms of UV radiation occur several hours after exposure.
- Conjunctivitis results four to eight days after exposure and lasts for several days.
- Detachment of the retina can occur with an overdose of UV radiation, e.g., by looking directly into the UV source.
- For many forms of radiation, damage is cumulative.
- Low exposure injuries occur mainly to the eye and are transitory.

b) Precautions

- Properly shield the UV lamp.
- Do not allow UV light to reflect from surrounding surfaces.
- Provide ultraviolet shields, ultraviolet goggles, or welders goggles.
- Provide eye protection for use in high power spark situations.
- Direct viewing of the sun should be avoided.
- Mercury vapor lamps that have their outer shield broken can be a dangerous source of UV radiation. The self-extinguishing lamps should be chosen when new lamps are being installed in order to avoid this potential hazard.

2. Microwave

Stray radiation is an associated possible hazard with the use of all microwave equipment. All microwave equipment should be regularly checked with a testing device that measures at least up to 2450 MHz.

a) Microwave Optic Kits

- These kits are available through science supply catalogues.
- They are within the safety range.
- The range or construction of the generating source should not be altered.
- Microwaves should not be directed toward the body for any length of time.

b) Microwave Ovens

- These ovens should not emit more than five mw/cm^2 at a distance of five centimeters.
- Large amounts of heat can be generated by microwaves in living tissue in very short periods of time.
- Microwaves can cause serious tissue damage without the individual sensing this damage.
- An individual with a pacemaker should not be near an operating microwave oven.
- Adhere to maintenance procedures (e.g., check the door for loose seals, damaged grid, and loose hinges).

- Metal objects must not be placed in the oven.
- The interior of the oven must be kept clean.
- Do not look through the door's grid while the oven is operating.

Students should be instructed in the proper use and the dangers of microwave equipment and the associated radiation hazards.

3. Laser

The term "laser" is an acronym of Light Amplification by Stimulated Emission of Radiation. Lasers are becoming increasingly common in schools, as they are in industry. The physics teacher should be aware of the associated hazards with their use, and students should be instructed in the safe use of lasers.

a) Health Hazards

- In working with lasers the greatest danger is the accidental focusing of a laser beam on the eye; opthomological examinations at regular intervals should be carried out on anyone working with lasers.
- Eye damage can be produced at any power level.
- The epithelial cells on the outer surface of the cornea, when irradiated, are killed and will slough off a few hours later. This sloughing off is accompanied by much pain.
- Retina damage may be produced by light pulses entering through the lens, being focused on the retina, causing a permanent blind spot.
- Should the optic nerve or the fovea (area of extremely fine vision) be affected, permanent or severe damage may result.
- The maximum laser energy density at the pupil of the eye should not be greater than 10^{-9} joule cm^{-2} ($\equiv 10$ μj m^{-2}), (including a safety factor of 10).
- When the lens of the eye focuses parallel laser light, the intensity on the retina may be 10^6 times greater than that received on the pupil of the eye.
- Retinal burns and lesions in the eye may be caused by invisible infrared radiation. Thus lasers that operate in the infrared may cause damage without the victim's awareness.
- Loss of sight is a potential hazard.
- Single or multiple laser beam reflections on the eyes can be every bit as damaging as a direct laser beam.
- The amount of energy entering the eye will increase when the pupil of the eye dilates in a darkened room; therefore, the level of general illumination must be kept high.
- Laser beams should not be allowed to strike exposed skin surfaces. Laser burns on the skin may occur with little warning or hint of their severity.

b) Guidelines for Using Lasers

- Check with your local school division to see if lasers are permitted to be used.
- Do not use high-powered laser systems. The maximum power output should rarely be over 0.5 milliwatt for a Helium-Neon Laser. Pulsed outputs could greatly exceed stated ratings.
- Do not leave an operable laser system accessible and unattended, or unlocked.
- The laser should be operated with a key switch in the primary power circuit rather than a type that can be operated by unauthorized persons.
- The danger area should be fenced off and a warning notice posted when a laser is in use.
- All optical components should be rigidly fixed and their deflection or reflection properties accounted for to prevent accidental altering of the beam direction by dislodged components, etc.

- All screens and metal surfaces used during laser demonstrations should be non-reflecting and fire-resistant, with backgrounds that are also non-reflecting and fire-resistant.
- Reflective surfaces such as walls, door knobs, table tops, may act as efficient mirrors; such reflected light may be as dangerous as a direct laser beam.
- A "light trap" to terminate the beam is recommended.
- Accidental pulsing of the laser must be prevented through proper design of the laser setups.
- These setups must minimize the possibility of electrical shocks from storage capacitors, power supplies, and other equipment.
- Flammable or explosive materials may be ignited by a laser beam.
- Sources which emit ultraviolet or infrared radiation must be shielded.
- Glasses used must be certified as protective devices for use with lasers for the particular wavelengths involved.
- Protection for all wavelengths cannot be achieved by any one type of goggle.
- Prepare and test demonstrations without pupils being present.
- The anticipated path of the laser beam should be kept clear on all sides of laboratory personnel.
- Block the beam when it is not needed - using shutter cap, etc.
- Do not allow the beam to radiate unless measurements or observations are being taken.
- Do not look into the primary beam under any circumstances, even with eye protection.
- Do not allow reflections to enter the eye, including those from the lens surface.
- Lasers should not be aimed with the eye because reflections are maximized.

4. Light

Each student has an individual tolerance and adaptability to light energy.

a) The dangers of strobed or pulsing lights should be noted. The effect has quite serious consequences for those with epileptic tendencies.
b) Contact lenses may present a hazard to the wearer during certain types of light experiments.
c) The teacher should not allow the students to experiment freely:
   - while looking directly into the light source with or without intervening lenses;
   - by directing light energy on flammable or explosive materials.
d) The high risks encountered in doing light experiments are found in situations where the teacher is not aware of the danger in using various types of light sources (mercury vapor, spectrum tubes, metallic arc lamps, strobe lights, etc.).
e) Hazard potential may be increased by placing lenses and/or combinations of lenses between the source of light and the eyes.
f) Care should be taken to prevent pupil injuries due to sharp edges on mirrors, prisms, and glass plates.
   - Inspect before handing to pupils; remove sharp edges by grinding or using sandpaper/emery cloth.
   - There are special plastic dips for covering sharp edges.
   - Pupils should be encouraged to report at once any sharp-edged apparatus.
g) Direct viewing of the sun must be avoided.
   - The use of heavily tinted plates or glasses may not protect the eye from all dangerous wavelengths found in the sun's rays or from the misuse of such equipment.
   - Indirect (projections, cameras, T.V., etc.) methods of viewing should be used.

J. Solar Energy Activities

The sun is used as a direct source of energy in many areas of experimentation and demonstration. Devices used for these activities should be handled with respect.

1. Hazards in the Use of Solar Energy

a) The teacher should be aware of students who may have a photosensitive skin condition.
b) Students should not be allowed to look directly at the sun or into other areas of concentrated heat and/or light, or to become sunburned while performing solar energy activities.
c) Solar cooking devices have high temperatures at the focal point.
d) Do not direct the area of high temperature on another person or on flammable materials.
e) Avoid the build-up of temperatures in a closed container unless it is specified for an experiment.

XII. BIOLOGY

A. Introduction

Safety in the biology laboratory requires basically the same attitudes, practices, and procedures necessary in all scientific experimentation; that is, the establishment of and adherence to clear guidelines in the use of facilities and equipment; familiarity with the objectives of the particular activity by all participants; and the provision of appropriate safety equipment and methods of dealing with accident or injury.

B. Facilities and Equipment

The biology laboratory basically resembles the chemistry laboratory. Some notable differences are a 71 cm bench height rather than the 76 cm height found in the chemistry laboratory; less fume hood space; and special storage requirements for biological specimens, instruments, and equipment. Ideally, a biology laboratory should include the following features:

1. Physical Facilities

a) flooring which will neither be slippery nor transmit an electric shock when wet
b) two unobstructed exits per laboratory
c) CSA or local authority approval on all equipment
d) master shut-off switches and valves which are clearly marked and easily accessible to the teacher
e) sturdy furniture with round corners and edges
f) adequate number of electrical outlets, removed from water source
g) wide aisles
h) ground fault interrupters and non-sparking switches
i) adequate number of sinks, with rubber or plastic mats over the drains
j) fume chamber that maintains a minimum face velocity of 0.5 meters per second with a full sash opening
k) alcohol or gas burners of metal construction
l) ready access to shelves so that apparatus or containers can be easily and quickly reached and replaced

2. Safety Equipment and Apparel

a) a well-stocked first aid kit
b) fire extinguishers, fire blanket, and sand pail
c) safety signs posted where appropriate
d) hand-washing facilities and antibacterial soaps beside each sink
e) eye wash fountain and deluge shower station
f) an explosion shield for the demonstration table (could be shared with physics and chemistry)
g) chemicals or kits to deal with spills
h) disinfectants such as Dettol or 5% Lysol. Other brand names may be Bridine, Hibitane, Savalon, or Pine Oil
i) laboratory coats or aprons to protect clothing and skin
j) ties for long hair
k) adequate supplies of protective glasses and gloves
l) ultraviolet sterilizer cabinet for goggles when goggles are shared

3. Storage and Waste Receptacles

a) explosion-safe refrigerators, safety cans, and vented storage cabinets for flammables
b) separately labelled waste containers for broken glass, solid waste, flammables, and specimen remains

c) racks or drawers with partitions for sharp tools
d) rimguard shelves, permanently fixed to the wall
e) storeroom doors and cupboards which can be locked
f) a waste disposal unit (garburator type)
g) adequate aquarium space for fish, snakes, turtles, and similar animals
h) animal cages (suggested by the Canadian Council on Animal Care) that have slide trays for food and waste disposal
i) microscope storage with fixed shelves in a locked cabinet
j) audio-visual and chart storage

C. Sterilization Techniques

The most effective sterilizing agent is heat.

1. Autoclave (Steam Under Pressure)

a) Operation

- Caution is required when using this equipment.
- Become thoroughly familiar with the manufacturer's instructions.
- Ascertain that the safety valve is in working order before use.
- Keep pressure under 20 pounds psi (130 kPa).
- Turn off and/or remove the autoclave from the heat source.
- Allow the pressure to return gradually to normal atmospheric pressure.
- Carefully open the safety valve before releasing the clamps.
- Under no circumstances should the cover be removed until the pressure is reduced to normal atmospheric pressure.

b) Usage

- Heat-protective clothing should be worn. Serious burns can be caused by superheated steam.
- Only distilled water should be used inside the autoclave.
- The autoclave should not be left unattended unless it is equipped with all the safety devices.
- "Sterile" indicator tape should be used with every load run.
- All glassware should be wrapped appropriately to maintain sterility.
- The cotton or foam plugs on the flasks should be covered with paper or cloth to keep them dry.
- Culture media, glassware, rubber, and cotton should be sterilized at a setting of 15 psi (97.5 kPa) for 15 minutes or as per specific manufacturer's instructions. Large quantities of media that are sterilized in flasks or bottles may require longer periods of sterilization (e.g., one-half hour).
- It may be necessary to use vaseline or paraffin wax on the lid rim to get a good air lock.

2. Dry Heat

Heat protective gloves should be worn when handling the hot equipment.

Materials	Time	Temperature Range in Oven
a) loose glassware, e.g., petri dishes, test tubes, flasks	> 1 hour	160° to 190°C (320° to 374°F)
b) packed glassware in containers, e.g., pipettes in foil or tin	> 2 hours	As above.

NOTE: Cotton and paper begin to char at temperatures 175°C (347°F).

3. Liquid and Gas

a) Liquid disinfectants should not be relied upon for complete sterilization.
b) Sterilizing gases are effective but should be handled carefully due to their inherent toxicity.

D. Microbiology

Microbiological studies present an interesting challenge to both students and teachers. However, there are many unseen hazards to which the teacher must be alert.

Non-pathogenic microorganisms may cause problems for susceptible persons (e.g., E coli). The peculiar nature of this susceptibility is such that it is difficult to separate pathogenic from non-pathogenic organisms. Teachers should exercise caution when ordering microorganisms. If there is any doubt as to the usage of a particular microorganism, contact the Medical College, Department of Microbiology, University of Manitoba, 700 Bannatyne Street, Winnipeg.

1. Specimens

a) Many teachers collect ditchwater as a source of specimens.
   - Algae, bacteria, and water molds are common.
   - Typhoid, botulism, schistosomiasis (swimmer's itch) may also be present.
   - It should be assumed that field samples are contaminated.
   - Wash thoroughly after collecting water samples containing microorganisms.
b) Tetanus microbes are possibly present in soil.
   - All cuts in the skin should be covered.
c) Be certain that any hospital-donated gifts (e.g., slides, syringes) are decontaminated.
d) Pathogenic organisms should not be made available to the students. The teacher should handle all cultures of microorganisms as if they contained pathogens.
e) Staphylococcus albus should be used in place of Staphylococcus aureus.
   - Staphylococcus aureus may mutate to a drug-resistant pathogenic variety.

2. Teacher Preparation

a) Culture tubes and petri dishes should be handled with care.
   - A secondary unbreakable container to contain any breakage should be used.
   - Infectious aerosols may rapidly disseminate as a result of breakage.
b) The leftover sterile melted agar should be disposed of before it becomes contaminated by omnipresent organisms in the air.
c) Aseptic technique should be practiced by the teacher before classroom use.
d) The classroom should be provided with the proper disposal containers and disinfecting equipment.
   - A separate container for metal, glassware, disposable cultures.
   - A jar of disinfectant for slide decontamination.
e) The pre-lab should be prepared to include all hazard warnings.
   - Microbiological techniques from handling the specimens through to disposal should be emphasized.

3. Student Precautions

a) Eating and drinking should not be permitted in the laboratory.
b) Refrigerators in the laboratory should not be used for food storage, especially if microbes are being refrigerated.
c) Work area should be kept clean.
   - All purses, coats, books, etc., should be removed except those materials necessary for the experiment.
d) The experiment should be confined to as small an area as possible to avoid contamination.
e) The work area should be covered with disposable material.
f) Protective clothing should be worn, e.g., laboratory coat, apron, old shirt.
g) Hands should be kept away from the facial area.
h) Assume the culture contains disease-bearing organisms and act accordingly.
i) Carelessness, which can produce contamination of cultures, should be avoided:
   - coughing on an open plate;
   - leaving the petri dishes open for long periods of time;
   - tapping petri dishes, which may release and distribute spores and pollen throughout the laboratory.
j) Petri dishes should not be opened after the dishes are inoculated.
k) The petri dishes should be taped together if the plates are to be passed around.
l) Cotton plugs or tube caps can be contaminated by shaking tubes containing cultures. Contaminated caps or plugs can generate harmful aerosols.

4. Inoculating Loops

a) Wire loops should be flamed prior to transferring microorganisms.
b) The loop should be allowed to cool before inserting it into the sample. The liquid in the sample will spatter if the loop is too hot.
c) Liquid cultures should not be agitated with the inoculating loops because harmful aerosols may be produced.
d) Care should be taken not to break the liquid film held by the loop as substantial atmospheric contamination could be produced.
   - Use smooth, not jerky, hand movements.
   - Do not shake the loop.
e) Wire loops should be flamed after transferring microorganisms.
   - Use the hottest part of the flame to sterilize the loop.
   - Be aware that boiling and vaporization of the material may produce harmful aerosols before all the organisms are killed.

5. Pipetting

The hazards of pipetting fall into three categories: the accidental swallowing of liquids, mouthpiece contamination, and aerosol production.

a) A pipetting bulb or other device should be used. Do not use your mouth.
b) The mouth end of pipettes should be plugged with cotton.
c) The pipettes should be used properly to minimize aerosol production.
   - Liquid should not be forcefully blown out of the pipette.
   - The pipette should not be used to bubble air through a liquid culture.
   - When transferring liquids in a pipette, the tip should be kept immersed below the surface of the receiving liquid.
   - The pipette should be emptied by allowing the tip to rest against the side of the receiving container until all dripping has ceased.

d) The contaminated pipette should be immediately transferred to a germicidal solution, avoiding any loss of liquid during the transfer.
   - The mouth of the pipette should be sealed with the index finger or by careful control of pipetting bulbs.
e) The pipettes should be sterilized after use by appropriate methods (e.g., oven or autoclave).

6. Clean-up and Disposal

a) Proper disinfectant procedures should be used when cleaning up any accidental spills.
   - The spill area should be covered with a strong disinfectant.
   - Rubber gloves should be worn.
   - Ten minutes or longer should be allowed for disinfection.
b) The laboratory work area should be cleaned after the completion of the experiment.
   - Dettol, 5% Lipol, or other appropriate solutions should be used.
   - Work area coverings should be discarded in a labelled waste container.
   - Hands should be washed thoroughly.
c) Unwanted cultures should be disposed of and placed in a proper container for decontamination.
   - All old cultures should be collected and placed in a proper container for decontamination.
   - Old cultures should not be allowed to accumulate in the laboratory (e.g., in incubators or drawers).
   - Infectivity of cultures may be retained for long periods of time.
   - Hands should be washed thoroughly.
d) Students should not be allowed to operate an autoclave.
e) A dishwasher should never be used in place of an autoclave as a sterilizing device.
f) Microorganisms that have been cultured should be killed before washing and/or disposal.
   - An autoclave setting of 15-20 psi (138 kPa) pressure for 20 minutes is adequate to kill most cultures.
   - Even non-pathogenic organisms should be killed.
   - Carelessly discarded agar may allow pathogens from the air, which might normally evade notice, to increase greatly in numbers.
g) All disposable equipment should be sterilized prior to discard.

E. Human Biological Fluids

1. Blood

Observation of human blood cells or blood typing experiments require a knowledge of blood sampling techniques. The teacher should be thoroughly familiar with all aspects of the procedure. Blood-borne diseases (e.g., infectious hepatitis) can be transmitted throughout the class if aseptic techniques are not stringently employed.

The following listing of rules is presented to assist the teacher in safety conducting blood-letting experiments:

a) Parental permission should be obtained, as required by your school division.
b) Students should not be coerced to participate in blood-letting.
c) Facilities used to conduct these experiments should be kept clean, tidy, and sanitary.
d) It would be preferable that the instructor perform the puncturing of the students' fingers.
e) Use of automatic blood lancets should be avoided.
   - The adjustable setting may be too deep.
   - Sterilization is required between samplings.

f) Only disposable lancets should be purchased.
- Discard after one use.
- If the puncture is inadequate, discard and use another sterile lancet.

g) Proper instruction should be given in the use of the lancet, and proper procedures followed in obtaining the samples.
- Samples can be taken from the middle finger pad.
- The students should wash their hands with soap and water.
- The finger pad should be cleaned with 70% isopropyl alcohol. Commercially prepared, disposable alcohol packets are recommended.
- Excess alcohol should be removed with sterile cotton gauze pads.
- The finger should be held securely.
- Be careful not to contaminate the tip of the lancet when removing it from the package.
- The lancet should be aimed towards the middle of the finger pad.
- One swift, sure motion should be used to puncture the finger.
- A clean piece of gauze should be used to wipe away the first drop of blood.
- A drop of blood should be allowed to fall onto a clean microscope slide. Do not allow the finger and slide to come in contact.
- After sampling procedures are completed, a fresh alcohol pad should be used to clean the finger.
- A band aid should be used or ensure bleeding has stopped by compressing the wound with a clean, dry gauze pad.

h) Students should be made aware that blood typing experiments done in the schools have many sources of error and the results cannot be relied upon for accuracy.

2. Urine

If proper techniques are not followed, infections can be transmitted. Urine experiments can be safely conducted if the following rules are followed.

a) No student should be coerced to submit a urine specimen.
b) All work areas should be kept clean. The students should work in a layer of paper towels or a tray to contain any spillage.
c) All glassware used should be considered contaminated and soaked in a soapy water solution immediately after use.
d) Safe methods of determining glucose and albumin contents should be employed, as follows:

Glucose
- Benedict's solution is caustic. Protective eye wear should be worn.
- Water baths should be employed for the boiling of Benedict's and urine samples.
- Clinitest tablets or Tes-Tape can be safely used and have equally accurate results.

Albumin (Proteins)
- Nitric acid can cause spattering when heated. Protective eye wear should be worn.
- Nitric acid is corrosive and produces severe burns even when cold.
- Biuret solution calls for the same precautions as in the handling of caustic solutions.
- Albumin-Stix are available that are safer to use and have equally accurate results.

e) Microscopic examination of urine.

Centrifuging
- Centrifuges are used to separate cellular material from the suspending liquid medium.
- Care must be taken with all phases of the operation.
- The centrifuge should be carefully disinfected with a germicidal solution if any breakage of glassware takes place.

Examination of the Sediment

- The supernatant fluid should be discarded into a container labelled "liquid contaminated waste."
- A disposable wooden stick should be used to remove some of the sediment to place on the microslide.
- These sticks should be disposed of into a jar with disinfectant solution.
- Too large a drop should not be placed on the slide.
- Only unchipped microslides should be used.
- A coverslip should be placed over the drop of sediment.
- Used slides should be disposed of in a container of disinfectant solution.
- All experimentation with urine requires scrupulous handwashing after completion of the experiment.

3. Saliva

The mouth contains many bacteria. The teacher should, therefore, consider all specimens of saliva as contaminated specimens, and ensure that the rules of handling contaminated specimens are followed.

F. Epithelial Cell Study

Exercise caution when obtaining samples of epithelial cells from inside the cheek.

1. Students should be cautioned against damaging the cheek tissue.
2. Pointed instruments (e.g., dissecting needle, scalpel) should not be used.
   - The blunt edge of a flat toothpick or a clean wood splint should be used.
3. The toothpicks or splints should be placed into a container (e.g., plastic bag) for disposal immediately after use.

G. Diets

Experimentation that restricts protein and carbohydrate ingestion by students is not recommended in spite of the effective and rapid results that can be demonstrated. Medical conditions (e.g., borderline diabetes) may be revealed. Thus, this type of experimentation is of questionable use and should be avoided.

H. Heart-Rate Experimentation

Teachers should be aware of any medical problems their students may have. In any experiment involving a change in heart rate (e.g., running in place) caution must be exercised, and the student's heartbeat should not be allowed to exceed 200 beats per minute.

Circulatory experiments of this type may be performed with invertebrates or other small animals. Refer to page 78 for information on the use of live animals in the classroom.

I. Osmosis Experiments

a) Care should be exercised when inserting glass tubing through a rubber stopper.
   - Lubricate the end of the glass tubing with glycerin prior to insertion.
   - Grasp the tubing near the end to be inserted.
   - As an added precaution, wrap the tubing with cloth.
   - Use a twisting motion during insertion.

b) If a thistle tube is employed, the following steps should be taken:
   - Avoid grasping the bowl.
   - Grasp the tubing of the thistle tube near the rubber stopper.
   - Insert into the stopper as described above.

c) Various biological materials such as potatoes, carrots, and eggs are commonly used.
   - Use only fresh materials which are not decayed or decaying.
   - Refrigerate the material if used more than a day.

J. Extraction of Chlorophyll

A popular laboratory exercise is the extraction of chlorophyll with alcohol.

a) Only Pyrex or other heat resistant glassware should be used.
b) Approved safety cans should be used to avoid accidents when dispensing alcohol.
c) When using alcohol the following precautions are essential:
   - Use a water bath heated on an electric hot plate.
   - Never use an open flame.
   - If alcohol ignites in a beaker, cover the beaker with a heat resistant pad (e.g., ceramic plate).
   - A fire blanket may be used if burning alcohol runs over the table.
   - A fire extinguisher (class B, C, or ABC) may be necessary.
   - Be alert for the potential hazard of students' clothing catching fire in the above situation.
d) Be prepared to initiate full-scale fire procedures if necessary.

K. Chromatography (Column or Paper)

Solvents used in chromatography experiments should be used primarily in a fume hood or in a well-ventilated room.

a) Acetone and ether are toxic.
b) Nausea, narcotic effects, headaches, and other symptoms indicative of more serious consequences may be induced.
c) Ethers can form peroxides upon standing.
   - The formation of these peroxides can be inhibited by the presence of iron wire inside the container.
   - In any case, ether should not be kept longer than six months.
d) Extreme caution is necessary in the use of ninhydrin reagent.

L. Animals

1. Preserved Specimens

a) Specimens may be preserved in formaldehyde (HCHO) when received in the school.
b) Formalin contains 30-50% formaldehyde and may contain 6-15% methanol.
   - Formaldehyde and formalin are both carcinogens.
c) Formaldehyde reacts with hydrochloric acid to form Bis-chloromethyl ether, which is a well-known carcinogen.
   - Preserved specimens should be stored in an area separate from acid storage.
d) Formalin may irritate the nose, throat, lungs, eyes, and skin, and may cause allergic or other reactions if exposed to the skin or inhaled.
   - If the teacher is aware that a student has an allergy to any preservative, a protective barrier (e.g., rubber gloves or vaseline) should be provided to the student.
   - Whenever formalin is used, it is essential that adequate ventilation be provided.

- Protective equipment should be worn (gloves, goggles, apron) and tongs or forceps used (depending on the size of the specimen) whenever removing specimens from formalin solution.

e) Specimens should be thoroughly rinsed in running water, soaked over night, drained, and rinsed again before use.

f) The venom of preserved poisonous snakes is always toxic.
- Do not remove these specimens from their containers.
- Remember that the fangs of a dead rattlesnake can still scratch and infect a handler.

g) Violent allergic reactions may occur to both students and teachers when examining insect collections.
- Protein flakes and scales from the wings could be inhaled from the specimens.

2. Dissections

a) The teacher should be thoroughly familiar with the techniques and instruments used in dissections.

b) Competency of the students should be assured through proper instructions and hazard warnings by the teacher.

c) Dissection specimens obtained from abattoirs must be used with care, and protective equipment (e.g., gloves) should be worn because of the possibility of infection with Salmonella.

d) Specimens should be properly supported in the dissecting pan.
- Specimens should never be hand-held during dissections.
- The pan should contain black wax, paraffin, or similar holding material.

e) Scalpels or cutting devices should not have more than one cutting edge.

f) Always cut down on the specimen, and away from the self.

g) Due to the hazards of the sharp dissecting instruments, students should not walk around holding them.

h) Care should be exercised when taking, cleaning, and returning the instruments to the work stations.

i) The scalpels, blades, etc., should be washed under hot water.
- Be sure all residue has been removed.
- Dry thoroughly to prevent rusting.

j) Specimens should be disposed of in a plastic-lined garbage can with a lid.

k) The pans should be rinsed under hot running water after removing any solid residue.

l) Students and instructors should wash their hands with soap and water thoroughly before leaving the laboratory.
- An antibacterial soap is recommended.

m) All equipment should be returned to the storage room after completion of the dissections and cleaning.

3. Insect Preparation

Science projects or classroom studies often require students to be familiar with the proper method for collecting and preserving insects.

a) Any clean, large, screw-type lid jar (e.g., salad dressing jar) may be used.

b) A tissue should be placed in the bottom to absorb the killing agent.

c) Under no circumstances should potassium cyanide be used as the killing agent, nor should chloroform or ether be used in the laboratory because of their flammability and toxicity.

d) The lethal fumes could be provided by using ethyl alcohol or carbon dioxide.

e) About six drops of killing liquid added to the tissue in the bottom of the jar is generally sufficient.

f) A clean tissue should be placed on top of the tissue containing the liquid to keep the insects dry.

g) Label the jar: DANGER
POISONOUS FUMES
DO NOT BREATHE

h) If insufficient killing agent was used, recharge the jar by removing the top tissue and adding several drops more to the jar. Replace the top tissue with a clean one. The jar is now ready for use once more.

i) Jars can also be prepared by using a glass jar in which 2 1/2 to 4 cm (1 to 1 1/2 inches) of Plaster of Paris is placed in the bottom.
- Ethyl acetate is added and will be absorbed by the Plaster of Paris.
- The excess is poured off.
- This preparation will last ten months.

4. Canadian Council on Animal Care Guidelines

The Canadian Council on Animal Care has prepared a document entitled, "Guiding Principles Governing the Use of Live Animals in the Classroom at the Pre-University Level." This important document is reproduced below for your information.

GUIDING PRINCIPLES GOVERNING THE USE OF LIVE ANIMALS IN THE CLASSROOM AT THE PRE-UNIVERSITY LEVEL*

I. PURPOSE

These guiding principles have been prepared by the Canadian Council on Animal Care. They are recommended for use by Departments of Education and Boards of Education across Canada in order to ensure adequate safeguards exist for the proper care and use of animals in experimentation in the classroom, in the schools, in their jurisdiction.

These guidelines are not for use by students preparing projects for exhibit in Science Fairs. Students preparing projects for Science Fairs must adhere to the Youth Science Fair Regulations for Animal Experimentation, as prepared and distributed by the Youth Science Foundation, Suite 302, 151 Slater Street, Ottawa, Ontario, K1P 5H3.

II. PHILOSOPHICAL CONSIDERATIONS

Biological experimentation involving animals in the classroom is essential for an understanding of living processes. Such studies lead to a respect for all living things. All aspects of the study must be within the comprehensions and capabilities of the student undertaking the study.

Lower orders of life are preferable subjects for experimentation at the pre-university level. Such lower orders as bacteria, fungi, protozoa, and insects can reveal much basic biological information. They should be used for experimentation, wherever and whenever possible.

III. CARE OF EXPERIMENTAL ANIMALS

The care of experimental animals in the school should embody the principles laid down in the Care of Experimental Animals, A Guide for Canada, as prepared and distributed, by the Canadian Council on Animal Care.

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The following principles are necessary in order to provide optimal animal care:

a) The maintenance of animals in a classroom shared by students on a long-term basis is not recommended. Therefore, animal quarters specifically for housing of animals should be provided.

b) All experimental animals used in teaching programs must be properly cared for. Animal quarters should be made comfortable by provisions for sanitation, protection from the elements and have sufficient space for normal behavioural and postural requirements of the species. The living quarters shall have surfaces that may be easily cleaned, good ventilation and lighting, well-regulated temperatures and cages of sufficient size to prevent overcrowding. Animals must be protected from direct sunlight or other environmental factors which may disturb the well-being of the animal.

c) Food should be palatable, of sufficient quantity and balance to maintain a good standard of nutrition. Animals shall not be allowed to go below the maintenance level of nutrition. Clean drinking water shall be available at all times. Containers for food and water should be of a design made specifically for that purpose.

d) Colonies and animal quarters shall be supervised by a science teacher experienced in animal care. The students and other animal care staff shall be trained and required to handle the animals gently and humanely.

e) All animals must be disposed of in a humane manner. If euthanasia has to be carried out an approved humane method must be used and carried out by an adult experienced in the use of such procedures.

f) The use of animals must comply with existing local, provincial or federal legislation.

g) The procurement and use of wild animals and birds must comply with the Migratory Birds Convention Act of Canada, the Convention on International Trade on Endangered Species of Wild Fauna & Flora (ratified by Order in Council July 3/75) as well as any existing legislation at the Provincial level concerned with wild animals and exotic species.

IV. EXPERIMENTAL STUDIES

1. All experiments should be carried out under the supervision of a competent science teacher. It is the responsibility of the qualified science teacher to ensure the student has the necessary comprehension for the study to be undertaken.
2. Students should not be allowed to take animals home to carry out experimental studies. All studies involving animals must be carried out in a suitable area in the school.
3. All students carrying out projects involving vertebrate animals must adhere to the following guidelines:
   - A. No experimental procedures shall be attempted on a vertebrate animal that should subject it to pain or distinct discomfort, or interferes with its health.
   - B. Students shall not perform surgery on vertebrate animals.
   - C. Experimental procedures shall not involve the use of:
     - a) microorganisms which can cause diseases in man or animals.
     - b) ionizing radiation.
     - c) cancer producing agents.
     - d) drugs or chemicals at toxic levels.
     - e) alcohol in any form.
     - f) drugs that may produce pain.
     - g) drugs known to produce adverse reactions, side effects, or capable of producing birth deformities.

D. Experimental treatments should not include electric shock, exercise until exhaustion, or other distressing stimuli.
E. Behavioural studies should use only reward (positive reinforcement) and not punishment in training programs.
F. If egg embryos are subjected to experimental manipulation, the embryo must be destroyed humanely 2 days prior to hatching. If normal egg embryos are to be hatched, satisfactory humane considerations must be made for disposal of the young birds.

4. The use of anaesthetic agents, by students, is not recommended and in the case of some anaesthetics not permitted by law.
5. Information on the care, housing and management for individual species, as well as suitable experiments for use at the pre-university level, may be obtained from the Canadian Council on Animal Care, 151 Slater Street, Suite 1105, Ottawa, Ontario, K1P 5H3.

Revised May 1975.

5. <u>Considerations Before Using Live Animals</u>

The advancement of knowledge about life processes and the understanding of life itself is the basic aim in studies involving animals.

Living animals in a school laboratory create an environment that can be one of the most pleasant aspects of teaching science. Most students respond positively and naturally to animals.

However, when animals are present in the school, there is a need to consider safety and to acquire a technical knowledge relative to their care and handling. These considerations are mutually supportive.

a) The onus is on the teacher to determine the local regulations regarding keeping warm-blooded animals (including birds) in the classroom.
   - Permission of the principal may be required.
   - There may be a limitation on how long these animals may be kept in the classroom (e.g., 14 days).
b) The onus is on the teacher to determine the local, provincial, and federal regulations regarding experimentation on animals.
c) When purchasing mammals, only recognized scientific supply companies or suppliers should be used.
   - Documentation which indicates that the mammals are free of disease should be provided.
   - Some commonly used mammals in schools are gerbils, hamsters, rats, mice, guinea pigs, and rabbits.
d) Teachers should not try to "cure" animals brought in by students.
e) Animals found along a highway should not be used for dissection.
f) Teachers should have available information relating to the care and handling of specific animals.
   - Students or teachers who handle animals should recognize that each is a potential threat, particularly mammals.
   - As a general rule, poisonous snakes, disease-carrying insects, and harmful spiders should not be kept in a classroom.
   - Any animals capable of inflicting a venomous bite should not be kept.
g) Students may bring some marine animals to the school that they have obtained from other areas of Canada (e.g., sea urchins, fish, octopuses).
   - Handle each of these animals with care.
   - Octopuses can attach directly and inflict a sharp wound.
   - Infection may result from foreign proteins being introduced into the body through the wound.

h) Separate newly arrived animals from established live stock for at least ten days.
   - This allows the health of the animals to be ascertained.
   - All wild animals should also be isolated outside the classroom for at least a week.
   - The use of wild animals as laboratory specimens should be discouraged as they are possible disease carriers.

i) Monkeys should never be kept in schools. They can carry herpes B virus which is often fatal to humans.

j) Precautions are necessary to minimize the chance of transfer of pathogens to humans from animal carriers.
   - Mammals used in a classroom should be inoculated for rabies.
   - The incubation period for rabies is from ten days to seven months after exposure.
   - Government regulations restrict the rabies vaccinations of some wild animals.

6. Housing

a) Animal quarters should be comfortable, secure, spacious, and sanitary.

b) Various types of caging are available.
   - Under certain conditions, plastic cages may be an appropriate choice.
   - Cleaning will be facilitated if the cage has a removable floor pan to collect debris.
   - The cage construction should be such that escape is prevented and student intrusion is minimized.

c) Sterilize all cages before use and routinely during use.
   - If a new animal is added, this is particularly important. An infectious organism from a previous inhabitant of the cage can be transmitted to a newly introduced animal, or be transmitted to the students or teachers.

d) To minimize the possibility of injury, affix "Keep Hands Off" signs or other appropriate signs conspicuously on the cage. This is particularly important if the animal is a biter or otherwise vicious.

e) Damaged cages should be promptly repaired or replaced.

f) Useful bedding materials may include Pine Dry, peat moss, and wood shavings.

g) Avoid high level, intermittent, intense noise and harsh, glaring lighting.

h) Avoid marked temperature fluctuations.
   - Suitable temperature ranges for animals vary.
   - Ensure that during evenings, weekends, and holidays the temperature of the animals' environment does not fluctuate greatly.

7. Diet

a) Proper diets, regularly scheduled feedings, and adequate supplies of fresh water are necessary to avoid illness.

b) Use proper containers for food and water and clean up any spills as soon as possible.

c) During weekend and vacation periods, animals must be supplied with adequate provisions.
   - Deprivation can result in the animals scratching or biting the handlers.

d) Alternate care must be provided during an emergency situation.

8. Cleanliness

a) The elimination of odors and the control of parasites or diseases is essential to maintaining healthy animals.
   - A schedule for regular cleaning and overhaul of the facilities should be prepared.

- Students should have specific roles in caring for the animals.
- The schedule and routines should be posted in the area.

b) Emphasis on scrubbing the hands after handling the animals or cages should be part of the laboratory routine.

c) All wastes should be removed and disposed of in a sanitary, safe manner.

9. Common Laboratory Animals: Physiological Data

	Floor Space (cm^2)	Environmental Temp. Range (C)	Relative Humidity (%)	Water Consumption (ml)	Adult Food Consumption (grams)	Litter Size	Weaning Age (weeks)	Eyes Open (days)	Breeding Age (months)	Breeding Life (years)	Breeding Season	Gestation Period (days)	Resp. Rate (Range) (breaths/min.)	Heart Rate (beats/min.)	Life Span (years)	Maximum (years)
Rabbit	2800	7-10	45-50	300	180	1-13	8	10	6-7	1-3	any-time	31	53 (45-65)	200 (120-300)	6	15
Rat	370	7-10	45-50	35	10	6-9	3-4	10-12	2-3	1	any-time	21	85 (65-110)	375 (350-400)	3	4
Guinea Pig	650	7-10	45-50	145	12	1-8	2-3	birth	3	3	any-time	68	90 (70-100)	155 (150-160)	3	7
Hamster	320	7-10	55-65	30	10	1-12	3-4	15	2	1	any-time	16	83 (35-130)	450 (300-500)	1	2
Gerbil	320	21-24	45-50	none if green fed	11	1-10	3	18-21	3-4	3	any-time	24	95 (70-120)	450 (260-600)	2	4
Mouse	370	7-10	45-50	6	5	1-12	3	11	2	1	any-time	20	160 (80-240)	600 (300-750)	1.5	3

10. Maintaining Records

If animals are used by a biology teacher for observation or experimentation, record maintenance is essential. Such records are useful documentation that the teacher has provided care and safety supervision of the animals.

A sample of a suggested record form is provided on the following page.

INDIVIDUAL ANIMAL RECORD

SPECIES _____ LOCATION _____

SERIAL # _____ COLLAR # _____ SOURCE _____

DATE REC'D _____ SEX _____ AGE _____

WEIGHT _____ BODY LENGTH _____ TAIL LENGTH _____

RABIES IMMUNIZATION DATE _____

HEIGHT AT SHOULDERS _____

COAT COLORS _____ COAT TEXTURE _____

DISTINCTIVE MARKINGS _____

_____

_____

INITIAL PHYSICAL EXAMINATION BY VETERINARIAN

_____

_____

DATE _____ DOCTOR'S SIGNATURE _____

DATE QUARANTINE COMPLETED _____

DATE ASSIGNED TO EXPERIMENT _____ INVESTIGATOR _____

(Attach all subsequent reports relating to physcial exams, pathology, and therapy.)

11. Handling

Proper, humane methods of handling animals encourage students to have and to show a reverence for all forms of life.

a) Some students may suffer from allergies when in contact with, or in the presence of, certain animals or birds.
   - Students with asthma or bronchial ailments are usually most susceptible. These students should not be allowed to handle or be in close proximity with the animals.
   - Other seemingly harmless animal life (e.g., egg cases) may elicit allergic responses.
   - Symptoms may include slight headaches, itching, swelling of the limbs, wheezing, and tearing eyes.

b) Proper instruction should be provided to students in the handling, carrying, and general care of animals.
   - Only those students trained in handling procedures or under supervision during handling should be permitted to manipulate animals.

c) Frequent and proper handling results in less nervous animals.
   - Use deliberate and unhurried movements to avoid startling the animals.
   - Bites or scratches from the animals may result from improper and/or infrequent handling.
   - An animal should never be teased.

d) A pregnant, excited, young, injured, hungry, newly added, or tired animal requires special handling.

- The handler should use heavy leather gloves.
- Students and visitors should be advised about the dangers of inserting fingers into an animal cage.

e) Students with open cuts or wounds should never handle animals.
f) Any scratches or bites from animals should be thoroughly washed and reported immediately to medical or school authorities.
- Medical attention may be required if the skin is broken.
- The animal should be isolated and observed for ten days.

g) Students should keep their face and mouth away from animals.
h) Turtles should be handled only when absolutely necessary.
- They may carry salmonella, a disease lethal to man.
- Their habitat should be disposed of carefully.

12. Experimentation

Teachers have primary responsibility for school laboratory experiments involving animals.

a) The teacher should have empathy for, and be prepared to provide appropriate aid to, students suffering psychological distress, dizziness or fainting as the result of animal experimentation.
b) No surgery should be performed on any living vertebrate except by a qualified veterinarian.
c) The prevention of unnecessary pain and discomfort should be the underlying principle in the care and use of laboratory animals.
- Any experiments which will cause an animal pain, suffering, or discomfort should not be performed.

d) Be alert for changes from the normal behaviour, which usually occur in animals, especially aged animals, that have undergone experimentation.
e) The animal should be returned to its usual environment after a period of observation.
f) Eggs subjected to experimental procedures should not be allowed to hatch.
g) Laboratory animals should not be disposed of in the presence of pupils.

13. Aquariums

Many of the animals used in the laboratory can be successfully maintained in an aquarium. The following guidelines will help to ensure safety in maintaining aquariums and their inhabitants.

a) Leaks and breakage can be caused by moving an aquarium filled with water.
- Before moving an aquarium, remove most of the water.
- If an aquarium is to be emptied by siphoning, do not use mouth suction to start the procedure.
- Fill the tubing with water, immerse one end into the tank, and allow it to drain.

b) Aquariums may crack when near a heat source.
c) Electrical wiring should be properly installed and maintained to prevent electrical shock.
- Plug in the equipment to a circuit protected by ground-fault interrupters.
- Do not allow the level of water in the aquarium to reach the lights in the canopy.

d) Cover all sharp, exposed edges on the aquarium.
e) A disease similar to tuberculosis can be transmitted to humans by handling a diseased fish.
- Do not handle fish if hands are cut or injured.

14. Diseases

a) Precautions are necessary to lessen the chance of humans contacting diseases from animals. If an animal appears to be sluggish, weak, or unresponsive, the animal may have an undetected illness. Other danger signs may include the following:
- decrease in appetite,
- unhealthy appearance to hair, eyes, and/or skin color,
- strange odor from habitat,
- excessive sneezing,
- abnormal discharges,
- behaviour changes, such as an increase in bickering or fighting beyond usual pecking order behaviour,
- death of other animals in the cage.

b) Clean, sterile cages should be used to isolate all sick or suspect animals.

c) All bedding, food, etc., of the animal(s) in question should be incinerated.

d) The formerly occupied cages and used equipment should be thoroughly cleaned and sterilized.

e) Contact a veterinarian.

f) Proper disposal of the dead animals should be arranged (veterinarian or Humane Society).

g) A few samples of animal diseases that may be transferred to humans are listed below.

Causative Organism	Contact	Possible Results
Dog hockworm	Soil samples containing feces	Creeping eruption
Schistosome	Water samples from ditches	Swimmer's itch Schistosomiasis
Pinworm	Dogs, cats	Itching in anal area
Ringworm	Dogs, cats, rodents	Ringworm
R. rickettsia	Ticks, wild rodents, dogs	Rocky mountain spotted fever
Clostridium tetani	Wounds from animals	Tetanus
Mosquito	Outdoor environment	Allergic reactions, encephalitis, infection
Francisella tularensis	Rabbits	Tularemia, rabbit fever
Salmonella	Turtles, reptiles, and other animals	Gastroenteritis, enteric fever, septicemia
Bedsonia (chlamydia)	Birds, large and small mammals	Psittacosis Ornithosis
RNA virus	Carnivore	Rabies

h) Children may inhale or swallow worms carried by fleas. Ticks and mites attach themselves to creases and folds of the body after falling unseen into clothing.

i) The same precautionary attitudes to prevent the transmission of disease from laboratory animals should be maintained during field trips. Animals should be studied or kept for stimulation, learning, and enjoyment. Enjoy them safely!

M. Plants

Plants provide a source of learning in many of today's biology classes. There are, however, a number of hazards associated with plant use. These hazards, and methods of avoiding them, are described in the following section.

1. Seeds

Students should be cautioned about the hazards associated with seeds.

a) Seeds which may be dangerous may be placed in the mouth unconsciously.
b) Commercial distributors may coat the seeds and/or plants with hormones, fungicides, and insecticides.
   - Teachers should ascertain if the seeds they are purchasing have any chemical coating or spray.
c) If seeds are accidently inhaled to any degree, serious consequences could result.
d) Allergic skin responses may result from handling seeds.

2. Pesticides, Insecticides, Fertilizers

New chemicals are constantly being developed and coming on the market for use in agriculture. Many of these chemicals are not recommended for the biology laboratory because they may be considered dangerous to use. In selecting pesticides, follow the recommendation of the Plant Product Division of Agriculture Canada, and adhere to the manufacturers' instructions in their use. Be especially cautious when handling fumigants.

a) Precautionary Measures

- Students should be reminded that pesticides are hazardous chemical substances and instructed in the proper methods of working with plants that have been sprayed by pesticides.
- The use of pesticides should be supervised, ensuring that adequate ventilation is provided.
- All chemicals should be properly labelled.
- The label should be read three times: when removing the chemicals from the shelf; when dispensing; and, when returning them to the shelf.
- The chemicals should be kept in their original containers, tightly closed, and stored in a locked cabinet.
- Everyone involved in experiments should be required to wear appropriate protective clothing (e.g., goggles and gloves).
- Animals should be kept out of the area where chemicals are being used and aquariums should not be exposed to the pesticide(s).
- If a student ingests or has eye contact with the chemicals, appropriate action should be taken.
- Any exposed skin contact should be flushed and a watch maintained for signs of burning or allergic reactions.
- Hands should be thoroughly washed after handling pesticides.
- Proper disposal techniques should be used for old or unwanted chemicals.

3. Plant Growth Substances or Hormones

Rubber gloves should be worn and extreme care used when handling the chemicals listed below:
- Colchicine*
- Gibberellic Acid
- Indole Acetic Acid
- Indolebutyric Acid
- Maleic Hydrazide
- Naphthalene Acetic Acid
- Phosphon
- Rootone

* Extreme caution must be used due to the poisonous nature of colchicine.

4. Bread Mold, Spores and Pollen Experiments

a) Spores and pollen should not be excessively distributed through the classroom because some students may be allergic to them.
b) Bronchial inflamation has resulted from inhalation by students of pollen grains and the spores of many fungi.
c) The blossom's nectar and sap may be particularly toxic.
d) Allergic responses may be produced by excessive or prolonged exposure to fruit and/or bread molds.

5. Plant-Handling Precautions

Since not all plants have been thoroughly researched for their toxicity, it is important to follow common sense precautions, as listed below.

a) Do not place any plant part or fungus such as mushroom into your mouth unless absolutely sure of its safety.
b) Do not pick wild or cultivated plants indiscriminately.
c) Do not eat food after handling plants, without first scrubbing your hands.
d) Do not rub any sap (fruit juice) into the skin or open wound.
e) Do not inhale or expose your skin or eyes to the smoke of any burning plant or plant parts.
   - Oils and other vapors from the burning plant parts can make the student ill because of caustic and toxic chemicals which may be inhaled or may contaminate the skin and clothing.
f) Do not ignore symptoms that may indicate allergic responses to plants.
   - Students may not be aware of which plants will incite an allergic response.

6. Poisonous Plants

When poisonous plants are mentioned, most people immediately think of poison ivy and poison oak. There are, however, many other poisonous plants in addition to these: more than 700 are known to cause illness or death. Teachers should be familiar with the poisonous species which may be encountered in the classroom or on field trips, and should ensure that students are able to recognize these plants and are aware of their dangers.

a) The following are symptoms of plant poisoning:
   - gastrointestinal disturbance
   - sweating
   - constriction of pupils
   - increase in salivary and nasal secretions
   - muscle tremor
   - tightness in the chest
   - blueness under the fingernails and around the lips
   - indications of convulsions

b) If the teacher suspects plant poisoning:
- Act quickly.
- Induce vomiting immediately.
- Contact the Poison Control Centre.
- Implement their instructions.
- Save the toxic plant for identification.

7. Poisonous Plant Chart

Very few students (and teachers) recognize poisonous plants or poisonous plant parts in spite of the extensive availability of plants in classrooms, in greenhouses, and in the environment. The following chart lists some of the more common of these plants and the symptoms of poisoning by each.

Plant	Toxic Part(s)	Symptoms
Apple trees	Seeds	Contain a compound that releases cyanide when eaten. Some common symptoms that may appear within minutes are excitement, gasping, and prostration.
Arrow grass	Whole plant	Cyanide release. See apple trees above.
Autumn crocus	Bulbs	Vomiting and nervous excitement.
Azalea	All parts	Fatal. Produces nausea and vomiting, depression, difficult breathing, prostration, and coma.
Baneberry	Berries	Severe gastroenteritis.
Bittersweet	Berries	Nausea, anorexia, vomiting, colic, diarrhea, convulsion, coma, respiratory paralysis.
Black locust	Bark, sprouts, foliage	Weakness, nausea, and depression when the bark or seeds are chewed.
Bleeding heart (Dutchman's-breeches)	Foliage, roots	May be poisonous in large amounts. This plant has proved fatal to cattle.
Blue cohosh	Berries	Gastroenteritis.
Buckthorn	Berries	Purgative.
Buttercup	All parts	Severe injury possible to the digestive system by the irritant juices.
Cherries-wild and cultivated	Twigs, foliage	Release of cyanide when eaten. For symptoms see apple trees (above).
Crab apple	Foliage, seeds	Cyanide poisoning (see apple trees).
Castor bean	Seeds	Lethal dose for adults may be one or two seeds.

Plant	Toxic Part(s)	Symptoms
Daffodil	Bulbs	Nausea, vomiting, diarrhea. May be fatal.
Daphne	Berries	Fatal. A few berries can kill a child.
Dieffenbachia (Dumb Cane)	All parts	Irritation and intense burning of tongue and mouth. The air passage to the throat may be blocked by swelling at the base of the tongue, causing death.
Dogwood	Berries	Dermatitis.
Elderberry	Shoots, leaves, bark	Nausea and digestive upset. Poisoning has been caused by using the pithy stems as blowguns.
Elephant's-ear (Philodendron)	All parts	Intense burning and irritation of the mouth and tongue. Death can occur if base of the tongue swells enough to block the air passage of the throat.
English holly	Berries	20 to 30 berries may be fatal to children.
Foxglove	Leaves	Source of digitalis, a heart stimulant. In large quantities irregular pulse, mental confusion, and digestive upset may be produced. Can be fatal.
Golden chain	Beanlike capsules in which the seeds are suspended	Severe poisoning, excitement, staggering, convulsions, and coma. Can be fatal.
Honeysuckle	Seeds	Vomiting, diarrhea, convulsions, respiratory depression.
Horse chestnut	Leaves, flowers, and seeds	Nausea, vomiting, abdominal pain, gastroenteritis, muscle weakness, incoordination, convulsions.
Horsetails	Shoots, foliage	Harmful to animals.
Hyacinth	Bulbs	Vomiting, nausea, and diarrhea. Can be fatal.
Iris	Underground stems	Digestive upset. Symptoms severe, but effects not usually serious.
Jack-in-the-Pulpit	All parts, especially roots	Symptoms similar to dieffenbachia. Contains small crystals of calcium oxalate.
Jessamine (Jasmine)	Berries	Nervous symptoms and digestive disturbance. Can be fatal.

Plant	Toxic Part(s)	Symptoms
Jimson weed (Thorn apple)	All parts	Distorted sight, incoherence, abnormal thirst, delerium, and coma. Can be fatal.
Juniper	Berries	Digestive upset.
Lantrana camera (Red Sage)	Green berries	Nervous system, heart, lungs, and kidney affected. Can be fatal.
Larkspur	Young plant, seeds	Depression, digestive upset, and nervous excitement. Can be fatal.
Laurel	All parts	Difficult breathing, nausea, vomiting, depression, prostration, and coma. Can be fatal.
Lily of the valley	Leaves, flowers	Mental confusion, irregular pulse, digestive upset.
Marsh marigold (uncooked)	All parts, sap	Gastrointestinal irritant.
Mayapple	Apple, foliage, roots	Diarrhea possible if apples are overeaten.
Mistletoe	Berries	Can be fatal.
Monkshood	Fleshy roots	Nervous excitement and digestive upset.
Moonseed	Berries	Can be fatal. Resembles wild grapes in blue-purple color but contains a single seed instead of several small seeds (as in true wild grapes).
Mushrooms	All parts	May be fatal if ingested. Unless you are an expert on mushroom identification, do not ingest.
Narcissus	Bulb	Nausea, vomiting, diarrhea. May be fatal.
Nightshade	All parts, especially the unripe berry	Nervous symptoms and intense digestive disturbances. Possibly fatal.
Oaks	Foliage, acorns	Large amounts required for poisoning. Symptoms appear after several days or weeks. Kidneys are affected gradually. Do not allow children to chew on the acorns.
Oleander	Leaves, branches	Very poisonous. Severe digestive upset, heart effects, has caused death.
Poinsettia	Leaf	One leaf can kill a child if it is ingested.

Plant	Toxic Part(s)	Symptoms
Poison hemlock	All parts	Historically used as a poison. Can be confused with a wild carrot in appearance.
Poison oak, poison ivy, and nettles.	All parts	Dermatitis, itchy, painful vesicular rash.
Pokeweed	Berries, roots	Gastrointestinal cramps, vomiting, diarrhea. May be fatal.
Potato	Vines, foliage, green tubers	Acute solanine poisoning, stupefaction, loss of sensations.
Primrose	Leaves	Dermatitis.
Privet, common	Berries, leaves	Severe gastric irritation.
Rhododendron	All parts	Fatal. Produces vomiting and nausea, depression, difficult breathing, prostration, and coma.
Rhubarb	Leaf blade	Possible convulsions, coma, and death from raw or cooked leaves in large quantities.
Rosary pea	Seeds	Death can be caused by a single seed.
Snowberry	Berries	Emesis and drastic catharsis.
Solanum	All parts, especially the berries	Nausea, vomiting, abdominal pain, diarrhea. May be fatal.
Star-of-Bethlehem	Bulbs	Vomiting and nervous excitement.
Tomato	Vines, foliage	Dermatitis, solanine poisoning if ingested.
Toadstools and related fungi	All parts	May be fatal.
Virginia creeper	Berries	Nausea, stupor, vomiting, bloody diarrhea. Permanent kidney damage may occur.
Water arum	Berries	Gastroenteric irritant.
Water hemlock	All parts	Painful and violent convulsions. May be fatal.
White snakeroot.	Foliage	Gastro-irritant.
Wild carrot	Foliage	Gastrointestinal irritant. Dermatitis.

Plant	Toxic Part(s)	Symptoms
Wisteria	Seeds, pods	Digestive upset - mild to severe.
Yew	Berries, foliage (Foliage more toxic)	May be fatal. Sudden death without warning symptoms.

N. Biohazard Symbol

The posting of a biological hazard warning sign is highly recommended to signify the actual or potential presence of a biohazard and to identify equipment, containers, rooms, materials, experimental animals, or combinations thereof, which contain or are contaminated with viable hazardous agents.

The term "biohazard" is defined as meaning only those infectious agents which present a risk or potential risk to the well-being of people.

The recommended biohazard warning sign is a symbol which is colored fluorescent orange or orange-red, with an optional background color which provides sufficient contrast to the symbol.

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SUPPLEMENTARY RESOURCES

Films*

Department of Education Library

No Room for Error #1929

Winnipeg: Bortnick Film Productions Ltd., 1980
17 min., sd., color. Level - junior and senior high

SUMMARY: Accident re-creations, scientific demonstrations, and solid safety instruction tempered with humour to hold the students' attention and stimulate discussion.

28 Grams of Prevention: Safety for Today's Laboratory #1176

Pittsburgh, Pa.: Fisher Scientific Co., 1975
28 min., sd., color. Level - senior high and industry

SUMMARY: An excellent film on lab safety which covers the various aspects of safety such as labels, safety devices, storage, fire extinguishers, classes of fire, sprinkler or alarm systems, first aid, personal protective devices, disposal, and electric shock.

From Other Sources

Eye and Face Protection in a Chemical Laboratory

13 1/2 min., sd., color. Level - junior and senior high
This film may be borrowed from the Science Department, Kildonan East Regional Secondary School, 845 Concordia Avenue, Winnipeg, Manitoba, R2K 2M6; phone 667-2960.

SUMMARY: A film which illustrates the violence of chemical explosions and their danger to person and property. Ways are suggested for making the laboratory safer.

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*These films are available for booking by phone or mail through Film Booking and Reference Services, Department of Education Library, Box 2, Main Floor, 1181 Portage Avenue, Winnipeg, Manitoba, R3G 0T3.

If you are located outside Winnipeg, phone 1-800-592-0484.

Films must be booked with the film title number, the title and dates when required. Alternative dates should be suggested. The normal booking period is one week.

Films borrowed from the self-serve collection in the Library must be picked up in person, can be used for 5 working days, and must be returned in person to the Library.

(MAIL RETURN IS NOT POSSIBLE.)

A maximum of 2 titles at any one time can be borrowed.

For further information and assistance (not bookings) contact the Film Librarian at 786-0486 in Winnipeg or 1-800-262-8848, ask for extension 486 outside Winnipeg.

In the Movies It Doesn't Hurt

London: A C-I-L
25 min., sd., color. Level - junior and senior high
This film may be borrowed from Modern Talking Pictures Service, 143 Sparks Avenue, Willowdale, Ontario, M2H 2S5.

SUMMARY: A humourous treatment of a serious subject. Set in Christopher Wren School in England.

Safety: Isn't It Worth It?

Pittsburgh, Pa.: Fisher Scientific, 1981.
This film may be borrowed from Modern Talking Pictures Service, 143 Sparks Avenue, Willowdale, Ontario, M2H 2S5.

Science Laboratory Safety - Part I

19 min., sd., color. Level - junior and senior high
This film may be borrowed from the Science Department, Kildonan East Regional Secondary School, 845 Concordia Avenue, Winnipeg, Manitoba, R2K 2M6; phone 667-2960.

SUMMARY: This excellent film, produced by the Virginia State Department of Education, directly addresses the school laboratory safety issue.

Science: Live to Tell About It

12 min., sd., color. Level - beginning university students
Toronto: York University, 1979.
Information is available from the Film Librarian, Scott Library, York University, 4700 Keele Street, Toronto, Ontario, M3J 1P3.

SUMMARY: Live action plus cartoons.

Charts

Laboratory Safety

Shows proper laboratory safety procedures that are valuable to the beginning student. There are 25 full color illustrations. Mounted for hanging. Dimensions are 76 x 112 cm.

Dangerous Materials Chart

Gives emergency procedures and hazardous properties of 132 dangerous materials commonly used in laboratories. First aid procedures and a place for emergency telephone numbers are included. The chart is in four colors on white, washable plastic with metal edges at the top and bottom. The overall size is 14 x 89 cm (45 x 35 in.).

Toxic and Hazardous Chemicals

Indicates the handling, storage, and disposal of over 300 toxic and hazardous chemicals, including precautions for use and storage and instructions on how to cleanup spills. Each chemical is rated for health, flammability, reactivity (704M system), eye, skin, swallowing, and breathing contact hazards. Carcinogens and tetratogens are identified, as are threshold limits - immediately dangerous to life and health values, flash points, ignition temperatures, and fire fighting procedures. Made of washable plastic, mounted for hanging. Dimensions are 89 x 114 cm.

Biological Hazards - Living Organisms

Identifies bacteria, parasites, viruses, plants, fungi, fish, reptiles, etc., that may cause toxic reactions; gives common and scientific names for almost 1000 organisms; and indicates methods of transmission. Made of washable plastic, mounted for hanging. Dimensions are 89 x 115 cm.

Posters

Illustrates proper handling of equipment, dispensing and weighing of chemicals, and common safety precautions and should impress upon students the need for good safety habits. Set of twelve; dimensions 35.5 x 25.5 cm (14 x 10 in.).

APPENDIX A: FIRST AID

First aid is the immediate, skilled application of accepted principles of treatment given to a person who has been injured or has suddenly been taken ill. Its purpose is not to treat, but rather to protect in emergency situations where medical assistance is not immediately available.

It is important that the teacher know how to proceed in the event a student becomes ill or is injured in the classroom laboratory, as most laboratory injuries need immediate and special attention in order to reduce or eliminate permanent effects.

In addition, teachers should be informed at the earliest opportunity of any pupil who suffers from a known medical condition such as haemophilia, color blindness, epilepsy, heart condition, allergies, hypersensitivities, hearing impairment, and diabetes. As well, the teacher is advised to know if any student requires prescribed medication that could affect classroom performance. In any serious injury or illness, competent medical personnel should be notified at once.

This appendix is based on St. John Ambulance, Emergency First Aid, Safety Oriented, 1977. Used by permission.

A. First Aid Tips for the Teacher

1. Make students aware of all possible laboratory hazards and how to deal with them.
2. Ensure that the students know the location of first aid kits, fire extinguishers, eyewash fountains, safety showers, and fire blankets.
3. Make students aware of the school's emergency/disaster procedures and post all emergency instructions concerning first aid procedures, fire, explosions, chemical reactions, and spillage conspicuously near the storage areas.
4. Emergency treatment should be given in the order of availability by the school physician, nurse, teacher, or other designated person who has had first aid training.
5. Notify the principal or person in charge of the school.
6. Communicate with the parents, if time permits, so that they can advise the school concerning the hospital or physician.
7. If the parent cannot be located, or if the injury is of such a serious nature that more than emergency treatment is immediately necessary, see that the child has prompt treatment by a physician or at a hospital.
8. If possible, contact the family physician or the school physician.
9. If the child is to be taken home, be certain that someone will be there to receive him or her. Stay with the child until the parent(s) or representative takes over.
10. Do not provide medical advice.
11. Fill out accident reports and send a copy to each person who has been designated to receive one.
12. Notify parents of all circumstances in relation to the accident and treatment.
13. Keep the principal notified of the action that has been taken.

B. The First Aid Kit

A basic first aid kit for school laboratories should include the following:[1]

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[1] Based upon the requirements specified in Manitoba Regulation 207/77, 17(3), Workplace Safety and Health Act. Winnipeg: Queen's Printer, 1977.

Equipment

First aid manual, current edition
First aid record book
12 safety pins
1 splinter tweezers, blunt nose
1 pair scissors, four-inch (10 cm)

Dressings

(each item to be individually wrapped to maintain sterility)
3 sterile 4" x 4" (10 cm x 10 cm) bandage compresses
16 sterile 3" x 3" (7.6 cm x 7.6 cm) pads
32 sterile adhesive dressings, 1" wide (2.5 cm)
2 sterile 1 sq. yd. (1 m-) gauze compresses

Bandages

3, 40" (1 m) triangular bandages
2, 2" x 6 yd. (5 cm x 6 m) roller bandages
2 rolls of 1" x 2.5 yd. (2.5 cm x 2.5 m) adhesive tapes
5 yards (5 m) tabular finger bandage with applicator

Antiseptic

An approved antiseptic.

C. Responsibilities of a First Aider

Your practical knowledge of first aid and common sense will dictate what you should do when you arrive at the site of an injury or illness. Obtain maximum information by looking, smelling, listening, and touching; be calm. Act decisively and take charge.

1. Assessing the Situation

a) Immediate and adequate treatment must be given.
b) Determine which casualties require the most urgent attention. (Breathing and severe bleeding have priority.)
c) Ascertain how many injuries the victim(s) has (have) obtained.
d) Reassure the conscious casualty that you have the situation under control.
e) Listen carefully to the casualty. Not only will you reassure the victim, but valuable information on conditions may be obtained.
f) Be conscious of the environment at the scene of the accident or injury, e.g., electrical hazards, poisonous gases.

2. Selecting the Appropriate Plan of Action

a) Obtain pertinent details about the accident by asking questions of the casualty and witnesses.
b) Observe and examine the casualty.
- Note the rate and depth of the victim's breathing. Apply artificial respiration if required.
- If unconscious, place in the recovery position unless fractures are suspected.
- If no pulse can be found, CPR (cardio-pulmonary resuscitation) should be initiated by a certified practitioner.
- Check for severe bleeding and control it if it is found. Examine the mouth, nose, and ears for blood and other materials.
- Question the victim to determine the source of pain or injury. Examine that part first.

- Systematically examine the victim starting with the head and neck, continuing with the spine and trunk. Finally, examine the upper and then lower limbs.
- Examine the scalp for bruises or bumps.
- If the casualty has said that there is neck pain, do not permit the casualty to move his head or neck. Immobilization of the neck may be achieved with a cervical collar or other improvisations.
- If the casualty has no neck pain, it is unlikely the neck is fractured.
- If possible, without moving the victim, feel along the centre line of the back. A fracture of the spine may be indicated by pain or tenderness at any spot.
- To determine if there are broken ribs or serious chest injuries, ask the casualty if there is pain when taking a deep breath and coughing.
- No internal injury is likely if the victim can pull in and push out the stomach without pain.
- No arm or leg injury is likely if the victim can move these limbs without pain. Immobile limbs should be felt gently for tender or swollen areas.
- Check to see if the victim is in shock, which is indicated by paleness of the skin, blueness in the nail beds, inner sides of eyelids, face, and lips. Hot and dry or cold and sweaty skin should be determined by touch.
- If the victim is nauseated, this symptom could indicate head injury or shock.

c) The first aider must decide whether or not to move a casualty. Will the move cause further injury? Is there danger of further injury by not moving the casualty? The seriousness of an accident may be increased many fold by unwise action.

d) The obtaining of medical aid as soon as possible is very important. Assure that this aid is being summoned. Meanwhile, administer first aid to the urgent needs of the casualty.

D. Respiratory Injury

If possible, move the casualty into the fresh air. Artificial respiration may be necessary. Medical aid should be obtained as soon as possible in cases of severe respiratory injury. The reporting of any known exposure to toxic, corrosive, or irritating gases is essential.

1. Artificial Respiration

THE FIRST MINUTES ARE VITAL - START ARTIFICIAL RESPIRATION AS QUICKLY AS POSSIBLE. If the brain is deprived of oxygen for more than three to four minutes, the brain is likely to be permanently damaged.

a) Make sure the casualty is pulled clear of immediate danger. Switch off electric currents or use insulating material to pull the victim away from the conductor if an electric shock causes unconsciousness.

b) Place the victim in a face-up position and remove any obstructions from the mouth and throat, e.g., chewing gum, loose or false teeth, plant material ingested during drowning, food.

c) Put one hand on the forehead and the other hand under the neck of the victim and tilt the head right back, raising the chin up. This procedure prevents the tongue from blocking the air passage in the throat.

d) Seal the victim's nostrils by pinching or resting your cheek against them.

e) Inhale deeply, seal your lips around the victim's mouth and quickly blow four breaths into the lungs until they are filled. Watch the chest rise.

f) After you remove your mouth, inhale while watching the chest of the patient fall.
g) Continue breathing into the victim about every five seconds (twelve times a minute).
h) If you cannot seal the victim's mouth for any reason, close the victim's mouth and blow through the nose of the victim at the same rate as above.
i) CONTINUE ARTIFICIAL RESPIRATION FOR AT LEAST ONE HOUR OR UNTIL MEDICAL AID IS AVAILABLE.

2. Choking

If a victim is not able to speak or breathe, they may indicate choking by clutching the throat. Because of the lack of oxygen, the skin will appear bluish.

a) It is important that the obstruction be removed immediately or, failing this, that air is gotten into the lungs past the obstruction.
b) If there is only partial obstruction, and while the choking casualty is breathing, do not interfere with the casualty's own attempts to remove the obstruction.
c) Using the flat of your hand, deliver several sharp blows between the shoulder blades of the victim.
d) If back blows are not effective, administer abdominal thrusts in rapid succession. Whether the casualty is seated or standing, this procedure may be carried out as follows:
   - Stand behind the casualty and wrap your arms around the casualty's waist.
   - Make a fist.
   - Place your fist with the thumb side slightly above the naval and below the rib cage.
   - Cover your fist with your other hand.
   - Press your fist into the victim's abdomen with three quick thrusts.
   - If necessary repeat the procedure.
e) Repeat back blows and thrusts until the airway is clear or until the casualty becomes unconscious from lack of oxygen.
f) To administer abdominal thrusts to a casualty who is lying down:
   - Place the casualty in a face-up position, or if the casualty is unconscious, in a face-down position.
   - Kneel down astride or close to one side of the casualty with your shoulders directly over the casualty's abdomen.
   - Place your hands on the victim's abdomen, with the heel of the lower hand below the rib cage and slightly above the naval.
   - Use quick thrusts into the abdomen.
   - If necessary, repeat the procedure.

E. Unconscious Persons

1. It is more difficult to determine what is wrong if a casualty is unconscious.

a) Ensure that the airway is clear and start artificial respiration immediately if the casualty is not breathing.
b) Make sure the airway is kept open if the casualty is breathing.
c) Bleeding or loss of control of bladder or bowels may be indicated by dampness over or under the casualty.
d) Control any serious bleeding before proceeding further.
e) Pay particular attention to the symptoms of head injury or internal bleeding; cuts or bumps on the head and fluids or blood from the mouth, nose, eyes, or ears.
f) An unconscious person must not be given liquids or medicines.

2. The Recovery Position

It is important to remember that an unconscious person is in danger of suffocation if left lying in the face-up position. For this reason, all (except if head and/or neck injury is suspected) unconscious casualties must be placed in the recovery position. Use gentle but firm movements when placing a casualty in this position.

a) Give maximum support to any injured area.
b) Use the clothing at the knee and hip to draw the far leg over the leg nearest you.
c) Turn the casualty into the position.

F. Bleeding and Cuts

1. Small Cuts

a) Clean the wound and wash well.
b) Cover with a small bandage and send the student to the nurse.
c) Be certain that all debris is removed from the wound.

2. Severe Cuts

a) If the blood is spurting, place a sterile gauze pad directly on the cut and apply firm, direct pressure.
b) Hand pressure alone may be applied if no sterile pad is immediately available.
c) Elevate the injury above the level of the heart if no fracture is suspected.
d) Wrap the injured to avoid shock, and get immediate attention. Never use a tourniquet.
e) If the dressing becomes blood-soaked, do not remove it, but apply further pressure dressings.
f) Reassure the injured person.
g) Get medical attention.
h) It is advisable to report to a medical officer for an anti-tetanus injection or toxoid boost.

3. Severe Arterial Bleeding and Pressure Points

A flow of blood that is bright red and spurting indicates bleeding from an artery. The bleeding due to a severed artery must be controlled as quickly as possible.

a) Firm pressure at an appropriate point on the artery must be applied between the heart and the wound.
b) The artery must be pressed onto the underlying bone to stop the flow of blood.
c) The appropriate pressure points may be located by feeling for the pulse.
d) In the case of arterial bleeding where the pressure point is in the groin, place both thumbs over the artery and press very hard.

4. Nosebleed

a) Set the person down with the head tilted forward.
b) Pinch below the bridge of the nose under the hard part.
c) Do not blow the nose.

5. Ear-Bleeding

a) Lie the victim down, face-up.
b) Raise the head slightly and incline it to the injured side.

c) Do not plug the ear with a dressing.
d) Get medical advice.

G. Eye Injuries

1. Contact Lenses

a) Students should be discouraged from wearing contact lenses in the laboratory, as capillary attraction may draw chemicals under a contact lens making water washing ineffective.
b) In the event an eye injury should occur to a student wearing contact lenses, the lenses must be removed immediately. To remove the lenses, press the skin and muscles at the outside of the eye and have the victim blink.

2. Chemical Splashes

a) Immediately flush the eye(s) with copious amounts of gently flowing water, forcing the injured eyelid(s) open if necessary.
b) If contact lenses are found to be in the victim's eye(s) they must be removed and flushing continued.
c) Continue the flushing, while holding the eyelid(s) apart for a MINIMUM OF 15 MINUTES.
d) Alkali (base) material in the eye requires a longer period of flushing than do strong acid solutions to leach out the damaging chemical.
e) Cover the area with a clean, dry dressing and get immediate medical attention.

3. Foreign Bodies

a) If a foreign body becomes embedded in an eye, do not attempt to remove it.
b) Cover the eye with a clean gauze pad.
c) Transport the victim to medical attention immediately.

H. Shock

The word shock has many meanings and may manifest itself in several forms.

Physical or emotional injury may bring about a state of collapse or "shock." This shock must be treated because, if not brought under control, it may be fatal. Inadequate supply of blood to the brain and other vital centres caused by either severe loss of blood or the pooling of blood in the abdominal region will weaken the blood circulation.

1. Causes

Shock can be caused by electric current, violent reaction to an allergen such as the poison from a bee sting, fall in blood pressure accompanying poisoning, or following a severe injury.

2. Symptoms

Symptoms may include: faintness, giddiness, complaint of blurred vision, collapse, pallor, clammy or cold skin or the breaking into a sweat, thirst, rapid weak pulse, nausea, vomiting, and anxiety.

3. Treatment

Remember that the expression "treat for shock" means treat the condition that is causing the shock.

a) Immediately attend to the respective priorities of breathing, unconsciousness and bleeding.
b) Serious fractures should be stabilized.
c) Cover burns with dry dressings.
d) Keep the victim warm. Do not use hot bottles or electric heating pads.
e) Keep the head of the casualty low.
f) If the victim has suffered a chest injury or a heart attack, place the victim in a position which affords the most relief from pain and discomfort.
g) Do not give the victim anything to drink. Moistening the lips may relieve the victim's thirst.
h) A blood transfusion may be necessary -- get the patient to hospital as quickly as possible.

4. Electric Shock

a) Remove the plug or turn the switch off on the device affecting the victim.
b) Do not touch the person in contact with a live circuit, or you may be seriously injured.
c) Obtain some type of non-conductor or insulator such as a stick or dry board to lift the conducting material so that the victim may be removed.
d) Initiate artificial respiration immediately if breathing has stopped.
e) Keep the patient comfortably warm in a semi-reclining position after breathing resumes.

Electric shock can cause cardiac arrest. Cardio-pulmonary Resuscitation (CPR) Basic Life Support should be administered.

However, improperly administered CPR can cause fractures or even be fatal to the victim.

This manual does not give instructions for the administration of CPR because it is a complex procedure which can only be learned through a certification program. CPR training provides the first aider with the correct techniques of providing heartbeat and breathing to victims of cardiac arrest.

For information and to register for certification in the use of CPR, contact the St. John Ambulance or the Manitoba Heart Foundation.

I. Burns

Note: Do not consider using chemical antidotes for any burns. Reactions producing further injury may be set up in this way.

1. Thermal Burns

a) Minor burns result in reddening and blisters. If a small area is involved, the burn should be immersed into cold water.
b) Major burns covering a large skin area or deep should be covered with a dry sterile dressing, and medical advice should be obtained.
c) Do not apply ointments, spray, home remedies, antiseptic preparations, or lotions to major burns.
d) Do not break blisters or remove tissue which are produced by burns.

2. Chemical Burns

a) Chemicals on the skin
- Flush with cold water immediately.
- Wash with soap and water.

- If no burn is visible, washing with soap and water is still required.
- Remove any jewelry to facilitate removal of any residual material.
- Burns should be checked the following day for possible delayed chemical action.
- Get medical attention immediately if any delayed chemical action is observed.
- Keep records noting the chemicals involved in any chemical burns.

b) Chemicals spilled on the body over a large area
- Quickly remove all contaminated clothing while using the safety or hand-held shower.
- Flood the affected body area continuously in cold water for 15 minutes.
- If pain returns, repeat the washing procedure.
- Do not use neutralizing chemicals, ointments, creams, lotions, or salves.
- Immediately obtain medical attention.

3. Electrical Burns

All electrical burns should be examined by a physician within 24 hours, as the seriousness of the burn might not be immediately apparent to non-medical personnel.

4. Cryogenic Burns

Cryogenic burns are similar to thermal burns (see preceding page).

J. Bone and Joint Injuries

In all cases, the victim must be taken to qualified medical aid.

1. Sprain

a) Apply cold compresses or ice packs.
b) Support and elevate the injury.

2. Fractures

a) Prevent further injury by making the injured part immovable until help arrives.

3. Dislocation

a) Support the injury in the most comfortable position.
b) Do not attempt to place the bone back in its socket.

4. Head - Unconscious Victim

a) Check for breathing.
b) Maintain an open airway.
c) Turn the victim to the recovery position.
d) Obtain medical aid.
e) Do not attempt to give anything by mouth.

Note: Any person who was momentarily unconscious as a result of a head injury must seek medical advice before resuming normal activity.

5. Neck and Spine

a) Do not move the casualty until skilled help arrives.
b) Keep the victim warm and reassure.

K. Chest Injuries

1. Seal off wounds that suck air.
2. Do not remove any foreign bodies from the wound.
3. Cover the wound.
4. Support any fractured ribs.

L. Abdominal Injuries

1. Cover the wound or protruding bowel with dry, clean dressing.
2. Do not give anything by mouth.
3. Raise head, shoulders, and knees.

M. Fainting

1. If a student feels faint, have the patient lie down with their legs elevated.
2. Loosen any tight clothing.
3. Ensure a fresh air supply.
4. If the student has fainted, place the patient in the recovery position as for unconsciousness.

N. Bites and Stings

1. Animal Bites

a) Obtain medical aid promptly.
b) Allow some bleeding to help cleanse the wound.
c) Use an antiseptic soap or detergent solution to wash the wound thoroughly.
d) Use running water as hot as the person can bear to rinse the wound.
e) Have the possibility of rabies or other infection determined as quickly as possible.

2. Insect Bites and Stings

A painful swelling accompanied by redness and itching will probably be the only symptoms produced by an insect bite or sting in most persons. Occasionally, an allergic reaction may be brought on by bee and wasp stings. During an allergic reaction, the casualty may exhibit the following symptoms:

a) Breathing difficulties.
b) Swelling and hives around the mouth and eyes.
c) Nausea and vomiting.

Obtain medical aid if these symptoms are evident.

3. Snake Bites

The only poisonous snake found in Canada is the rattlesnake. It may be found in certain parts of Ontario and the western provinces, including Manitoba. Fatalities from snake bites are rare in Canada.

Two tiny puncture holes are left in the skin when a rattlesnake bites. In the area of the punctures, a burning sensation is felt. Swelling and discoloration rapidly occur around the bite.

The aim of the first aid is to prevent the absorption of the venom.

a) Obtain medical aid as soon as possible.
b) Wash the affected area with soapy water.
c) Cool the area with ice packs or wet dressings.
d) Immobilize the affected limb.
e) Avoid unnecessary movement of the casualty.
f) If possible, kill the snake and retain it for analysis and identification.

Non-venemous snake bites should be treated as other animal bites. Seek medical advice.

O. Allergic Reactions

1. Allergy-prone individuals are usually aware of their conditions and will have prescribed medication. Assist the casualty in taking this medication.
2. Start artificial respiration if required.
3. If antihistamine creams are available apply as soon as possible.
4. If no antihistamine creams are available, apply a paste of bicarbonate of soda and water, rubbing alcohol or weak ammonia. DO NOT USE RUBBING ALCOHOL OR AMMONIA AROUND THE EYES.
5. For stings in the mouth, give a glass of water containing 2.5 ml (one teaspoon) of bicarbonate of soda.
6. If there is much swelling in the mouth, give the casualty ice to suck.
7. If there is difficulty in breathing, place the casualty in the recovery position.

P. Effects of Low Temperatures

1. Frostbite

Prevention is the best treatment for frostbite.

a) Bring the victim to a warm area.
b) Gradually warm the exposed body surfaces.
c) This may be achieved by placing the frostbitten part in contact with the first aider's body.
d) Do not rub a numb area or this will damage the skin.
e) Do not rub the area with snow or cold water. Deeper freezing and tissue bruising will result.
f) Do not apply any form of direct heat.

In the case of severe frostbite the area affected appears white and waxy and hard to the touch.

a) Contact a physician as soon as possible.
b) Take the victim to a dry, warm place.
c) If the feet are frostbitten, walking on the injury will increase the severity of the damage. Carry the victim if possible.
d) Supply blankets and a hot drink to the victim for further warming.

2. Hypothermia

Hypothermia is defined as a lowering of the inner body termperature causing severely reduced blood circulation and severe impairment of normal body functions.

a) Symptons

- Victim feels cold, needs exercise to warm up, shivers and feels numb.

- Shivering intensifies, victim becomes incoherent and stumbles.
- Victim is no longer able to care for himself.

b) First Aid

- The first aider should concentrate on the high heat loss areas such as the neck, the chest, and the groin.
- The victim may be warmed by the following methods:
  . Breathe close to the mouth and nostrils of the victim to provide warmth through inhalation.
  . Air may be warmed by using a makeshift tent and steam.
  . Apply hot, wet towels or blankets.
  . Skin-to-skin contact is one of the most effective warming methods.
- It may be necessary to place the victim, stripped, in a sleeping bag preferably next to two warm people, also stripped.
- If the victim is conscious, give hot, non-alcoholic drinks.
- Do not move the victim until he is completely rewarmed.

These few rules provide a broad overview of most of the situations in which first aid may be needed in the school laboratory. Each school may, however, have additional first aid procedures with which the teacher must be familiar in order to manage accidents and emergencies with dispatch and intelligence in order to minimize the possibility of permanent damage.

APPENDIX B: WIND CHILL FACTOR*

Nearly everyone is aware of how much colder it feels outdoors on a windy day as compared to when there is no wind, particularly in winter. This apparent 'coldness' is due to the more rapid cooling effect produced by the wind to make it feel colder than it really is. The combined effect of wind and low temperatures is experienced by most Canadians in just about every part of Canada. The effect can produce serious and often dangerous conditions.

Wind Chill Factor as described in this pamphlet is a measure of the combined chilling effect of wind and temperature. Although the actual calculation of the factor is based upon how fast water will cool with the combination of low temperature and wind, it has been found to be equally applicable to the cooling effect experienced by the human body and by an inanimate object.

The advantage of Wind Chill Factor over other measurements methods is that it represents a real rate of cooling, in other words how fast an object cools. For example, the combination of a specific temperature and wind speed can be related to how fast exposed flesh will freeze. On the average the value of 1625 watts per square meter represents the condition where exposed flesh will freeze. It also gives an indication of how difficult it is to maintain an object, for example a house, at a given temperature.

In the past it has been common practice to use an equivalent temperature (wind chill temperature) to relate wind and temperature. Unfortunately the values obtained by this method often have been beyond the experience of most people. For example, -50°C occurs in relatively unpopulated areas of Canada. More importantly the equivalent temperature still does not relate to the combined effect of wind and temperature on the human body. It also is too easily confused with the actual temperature.

EXAMPLES OF THE EFFECT OF WIND CHILL FACTOR

1. Water will freeze more quickly at high wind chill factors than at low.
2. The ability of an engine block heater to keep a car engine warm decreases with increasing wind chill factor.
3. The length of time a car can be left turned off before reaching the surrounding air temperature decreases with increasing wind chill factor.
4. With increasing wind chill factor there is an increase in the fuel needed to heat buildings, particularly when the building is poorly insulated.
5. Exposed flesh freezes more rapidly with higher wind chill factors.

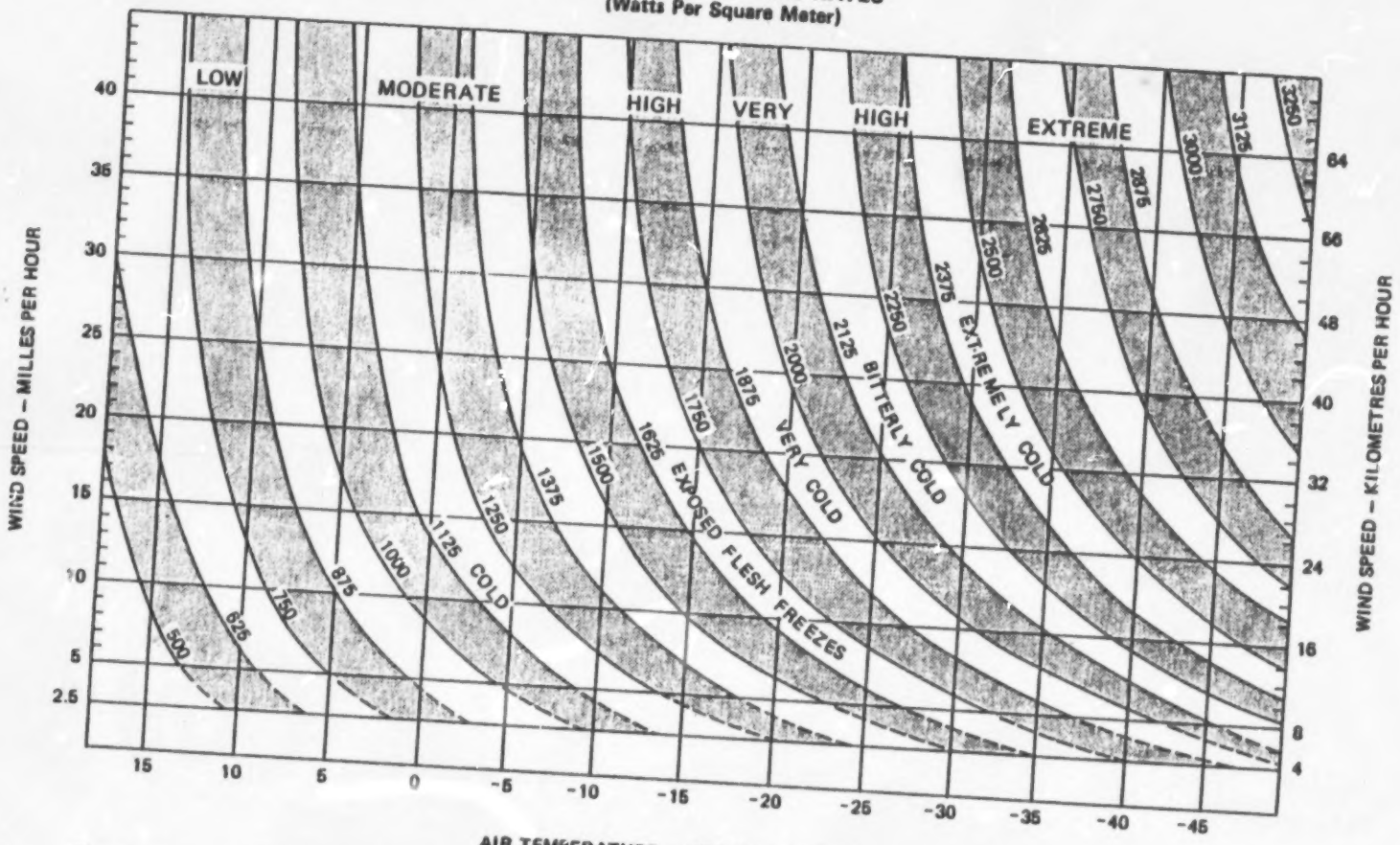
EXAMPLES OF WIND CHILL FACTOR

Wind Chill Factor	Comments
700	Conditions considered comfortable when dressed for skiing.
1200	Conditions no longer pleasant for outdoor activities on overcast days.
1400	Conditions no longer pleasant for outdoor activities on sunny days.
1600	Freezing of exposed skin begins for most people depending on the degree of activity and the amount of sunshine.
2300	Conditions for outdoor travel such as walking become dangerous. Exposed areas of the face freeze in less than 1 minute for the average person.
2700	Exposed flesh will freeze within half a minute for the average person.

The units of Wind Chill Factor used in this pamphlet are watts per square meter.

*From "Wind Chill Factor," published by the Atmospheric Environment Service of Environment Canada. Used with permission.

WIND CHILL COOLING RATES
(Watts Per Square Meter)



To determine the *wind chill factor* follow the temperature across and the wind speed up until the two lines intersect. The value of the wind chill factor can be interpolated using the labeled wind chill factor curves.

For example, at -10°C with a wind speed of 20 miles per hour the point of intersection lies between 1500 and 1625, or approximately 1570.

It is not recommended that wind chill factors be calculated for wind speeds below 5 miles an hour, since it is difficult to determine wind chill factors at these wind speeds and because other factors such as relative humidity become important.

APPENDIX C: THUNDERSTORM HAZARDS*

THE HAZARDS OF SEVERE THUNDERSTORMS

VIOLENT WINDS - GUSTS AND SQUALLS with speeds to 70 km/hour are not unusual with thunderstorms. Less frequently, thundersqualls of 115 km/hour are experienced. Such winds may cause structural damage to buildings, blow down signs, break down some trees and branches of trees, damage parked aircraft, etc. The occurrence of a tornado or a plow wind is a rare event but may be almost totally destructive when it hits. Tornado winds may be as great as 450 km/hour. Such speeds, coupled with their twisting action and sudden drop in atmospheric pressure as they pass over, cause buildings to literally explode. Animals, such as cows and horses, and large objects, such as cars and trailers, have been moved hundreds of metres by being rolled and pushed along the ground or by being lifted and dropped. Usually they are totally destroyed. Pieces of wood, metal objects and even straws become dangerous projectiles in the wind. A PLOW WIND may have speeds up to 200 km/hour -- sufficient to flatten trees and do severe damage to buildings.

LIGHTNING - This is a hazard that is present with all thunderstorms, but the frequency becomes much greater with severe ones. More people are killed by lightning than by tornadoes. Lightning strikes are the largest cause of forest fires and cause serious damage to electrical installations and buildings.

HAIL - Large hail, especially when driven by high winds, damages roofs, breaks windows, dents cars and ruins their finish, etc. People and animals may be seriously injured when struck by large hailstones.

HEAVY RAIN - Sudden downpours of cloudburst proportions cause flash flooding along creeks and ravines. Culverts and bridges are washed out or submerged. In cities and towns and on highways underpasses are often flooded.

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*From "Severe Thunderstorms," published by the Atmospheric Environment Service of Environment Canada, n.d. Used with permission.

SAFETY TIPS

GENERAL - Keep informed of the possibility of severe weather. Timely weather information is contained in the forecasts and advisories and warnings distributed through the news media from the weather office.

When outside, keep a "weather eye" open for the signs of severe weather -- frequent lightning, roll clouds and chaotic sky, unusual darkness and possible funnel cloud. Be prepared to seek shelter.

LIGHTNING - If caught outside keep away from high objects such as large trees or hydro poles. Don't be a lightning rod by carrying such things as a fishing pole or a golf club.

A place shielded by bonded metal, such as an automobile or an aeroplane, is a safe place from lightning, especially if it is insulated from the ground by rubber tires. An open tractor attached to a grounded implement is dangerous.

TORNADOES - An approaching tornado may be avoided by moving away from its path at a right angle.

Also, if caught outside, shelter may be found in a nearby sturdy building. Seek an interior room or hallway, preferably in the basement. If this is not possible, lie flat in a ditch or ravine and hang onto a small tree or shrub.

In a home, the safest place is the basement, under a sturdy table or a stairway. If there is no basement, a small room or hall near the centre, or on the side away from the approaching storm would be the safest location.

Avoid wide-span buildings and large open areas such as a supermarket, gymnasium or auditorium. In any building, keep away from windows, especially those on the side facing an approaching tornado.